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REPAIR SHOP DIAGRAMS AND CONNECTING TABLES FOR INDUCTION MOTORS

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CONNECTING AND TESTING D. C. MACHINES

REPAIR SHOP DIAGRAMS
AND
CONNECTING TABLES
FOR
INDUCTION MOTORS

Practical Step-by-step Information and Instructions for Connecting all Types of Windings for 2-phase and 3-phase Motors of 2-poles to 24-poles for Use by Armature Winders in Electrical Repair Shops When Rewinding and Reconnecting Induction Motors and by Maintenance Men in Industrial Plants When Changing Existing Winding Connections

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PREFACE

The object of this book is to furnish repair men and armature winders with practical step-by-step instructions on the laying out of coils for induction motor windings and connecting the ends of the groups of these coils in proper sequence of phase and pole groups for different types of windings used in motors of from 2- to 24-poles, 2- and 3-phase. The information presented can also be used when reconnecting the coil groups to satisfy changes in voltage, changes for operation on circuits of different number of phases, different frequencies or changes in speed of a motor.

Although sets of diagrams are available showing the theoretical layouts of coils in an induction motor with the required number of groups and connections for a balanced winding, the winder is required, when using such diagrams, to spend considerable time in studying out the connections for ends of pole-phase groups of coils before he can proceed with a connecting job and in most cases he finds it necessary to draw up a new diagram to represent the particular winding he is working on. In all of the diagrams of this book, this work has been done for him and each diagram is a practical shop drawing, marked with proper connections for the ends of all phase groups of coils so that they can be actually followed by the winder when making the connections. In addition, the diagrams are accompanied by tables that also give the number of coils in the different phase groups and the markings for the ends of these groups as indicated on the diagrams, to show the differences in markings for the ends of phase groups in different types of windings.

Repairmen and designers frequently use individual schemes for showing the layout and connections of induction motor windings which in the main aim to indicate the correct arrangement of pole-phase-groups of coils with the jumpers connecting the ends of these groups and the connections to the line terminals. The most used forms of these diagrams are the developed diagram and the single line diagram. By the developed diagram is meant that type which shows all the coils as they are put into the slots. Such a diagram may have something of the shape of a doughnut, or it may be shown opened up and laid out flat as on a table. The single line diagram shows the coil groups as a single line with the jumpers and line terminals connected to the ends of these groups.

In order to make a connection job as easily understood as possible, and to provide a uniform basis for the connections of all windings, the single line type of diagram is the one used throughout this book, supple-

mented with connecting tables that show for the different types of windings all the practical connections possible. A thorough understanding of the construction of the single line diagram for 2-phase and 3-phase windings can be quickly secured by studying Chapters IV and V. Chapter VI explains how the connecting tables are made up and how they can be used to draw up new diagrams, while Chapters I, II and III explain how these connecting diagrams and tables are used on a particular job.

The combination of connecting tables and diagrams to which they refer give all the developed type of diagram gives and a great deal that such diagrams do not give. After becoming familiar with these single-line connecting diagrams and tables much time can be saved through their use, for most reconnecting jobs and the connections for new windings can be made directly from the tables since in this book all of the possible connections that are used are included.

It is important to note, as explained in Chapter VI, that the tables showing connections for ends of coil groups have been compiled with the series winding as the base. All of these tables for top-to-top and top-to-bottom connections show the full lettering for the series connection only. Then for any parallel connection the lettering and numbering of ends of groups is changed only at the points on each group of the parallel connection line where a change is made from the standard series group lettering. Ditto marks are used to indicate when the series lettering is to be used for any other connection. In this way the differences in any two or more types of connections can be seen at a glance in the tables and the points in the winding where the changes must be made, when converting one connection to another.

It is also important to note that the diagrams and tables are lettered to indicate line leads and numbered to indicate jumper connections and star points in exactly the order that the winder would proceed when doing the job, so that the numbers in the tables show not only the number of the jumper used but also the order in which it is connected from the connection of the first coil group to the last one.

The diagrams and connecting tables have stood the test of a number of years of use by Mr. Roe and have been developed in such form that the average winder will find them easy to follow and to check. In somewhat different form the diagrams and tables have appeared in articles published in *Industrial Engineer* during 1923. They have now been revised and new diagrams and tables included to cover all practical connections for 2- to 24-pole, 2- and 3-phase lap windings. These diagrams are not intended for the use of designers but as practical shop instructions for winders and for repairmen who are called upon to layout and connect up new windings or reconnect existing windings for voltage and other operating changes.

While the diagrams and tables have been carefully checked several times, the authors will appreciate the reporting of any errors that are found.

D. H. Braymer
A. C. Roe

Omaha, Neb.
April, 1927

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REPAIR SHOP DIAGRAMS AND CONNECTING TABLES

CHAPTER I

HOW TO USE THE CONNECTING DIAGRAMS

In connecting induction motors the main job revolves around the proper grouping of the coils and the connecting of these groups. This book will take up these things and discuss the step-by-step details from the viewpoint of the shop man who does the work. The complete book will cover 2-phase and 3-phase windings having from 2 poles to 24 poles. This range covers almost all of the cases that will arise in practice. The diagrams and the data include both the short jumper and the long jumper connections for windings with 4 poles to 12 poles. For all the other numbers of poles (from 14 to 24 and also 2 poles) the information covers only the short jumper. This short jumper gives what is called throughout this book a "top-to-top" connection in which the adjacent pole-phase groups are connected together. The long jumper gives what is called a "top-to-bottom" connection in which all similar pole-phase groups are connected together, that is, every alternate group. This means that all north poles are connected in series and from the last north pole a short jumper is used to connect to the south poles which are likewise in series. Where the windings have 14 poles to 24 poles, a top-to-top connection only is given because on larger machines only the short jumper should ordinarily be used. The top-to-bottom jumpers would be quite long and awkward to handle. Of course there are a few cases when the long jumper is used for such machines.

On smaller machines the long jumper makes a neater appearing job and is easier to connect. Wherever the letters *T-T* appear in these diagrams this means that a top-to-top connection is shown. Likewise the letters *T-B* mean that a top-to-bottom connection is employed. When the coils are connected in groups of the proper number, the next step is to connect these groups together in the right relation. The diagrams and tables shown will enable a winder to make any kind of connection that is possible, either series or parallel, for 2 or 3 phases and for 2 to 24 poles.

It will be noticed that the diagrams for the 16, 18, 20, 22, and 24 poles show only the series connections for any winding. The connecting tables, however, corresponding to each one of these diagrams, tell how to make the change from the series to the parallel windings. The diagrams, it will be noticed, give both top-to-top and top-to-bottom, connections for windings having 2 to 12 poles. For 14 to 24 poles only the top-to-top connection is given. For the 3-phase machines both delta and star diagrams are shown.

How the Diagrams and Connection Tables Are Used.—In order to understand the use of the diagrams and connecting tables let us consider a 4-pole, 2-phase motor connected top-to-top. The diagram for this connection is shown in Fig. 24 and the corresponding table (Table 3) is shown also on page 67 with this figure. In this diagram there are 8 pole-phase groups represented by the eight sectors of the innermost circle. Each of these groups has a number as indicated by the figures at the center of the groups. At the beginning and the end of each group are other numbers. These indicate the numbers of the jumpers. For instance, in group 1 the figures *A* and *1* appear. This indicates that the *A* lead (one of the line leads) connects to the top of group 1. Throughout the diagrams, the top lead is the left-hand end of each group. Likewise, the bottom of group 1 is connected by jumper No. 1 to another group. This happens to be group No. 3, as may be seen from the diagram. (For further details on laying out new diagrams see Chapters IV and V.)

In the connecting Table 3, these figures which indicate the jumper numbers, are put down. As will be seen from the table the numbers for the jumpers attached to group 1 are *A* and *1*, to group 2 are *B* and *2*, to group 3 are *3* and *1* and so on. Likewise, the other connections besides the series are shown in this same table. The figures are changed only where it is necessary to change the location of jumpers on the winding.

It will be seen then, that if we have a 4-pole, 2-phase series motor connected top-to-top and we want to reconnect it in 2-parallel top-to-top, we must make changes only where the second line in the table differs from the first line. There is no change until we reach group 3 where it is seen that the top of the group instead of connecting to jumper No. 3 as before, now connects to A_2, or the other side of the line on the *A* phase. Likewise, changes are made in the jumpers going to the top leads of groups 4, 5 and 6. The tops of these groups were originally connected to jumpers 3 and 4. Therefore, to make the change, jumpers 3 and 4 are cut in half and the top of group 3 is connected to the original A_2 lead. Likewise, the top of group 4 is connected to the original B_2 lead. The other end of No. 3 jumper, which is attached to the top of group 5, is connected to the *A* lead, and the remaining end of No. 4 jumper, which is connected to the top of group 6, is now connected to the *B* lead.

Thus this table, and all other similar ones throughout the book, show at a glance where a change has to be made when reconnecting.

How the Tables Are Used to Connect a Rewound Motor.—When using the tables to connect a rewound motor a set of tags should be used. These tags should be numbered according to the connections indicated in the connecting table. For instance, for a 2-parallel, 4-pole, 2-phase, top-to-top connection (Fig. 25) there would be two tags each for the following figures and letters: A_2, A, B_2, B, *1*, *2*, *5*, and *6*. After these tags are made they may be put on in the following manner. Face the connection end of the stator and call the left-hand lead of a stubbed-up group, the top lead of group No. 1. On this lead put an A tag. Then on the bottom or right-hand lead of the same group put a No. 1 tag. The next group to the right is called No. 2 and on this group are placed the B tag and the *2* tag. Then follow this out according to the figures and letters in the connecting table. After all these tags are on, then put jumpers between the group ends which have similar numbers, the two tags which have No. 1 on them, the two tags which have No. 2 on them, etc. Connect all the tags with A to one line lead and with A_2 to the other line in the same phase. Likewise, connect the B phase to the tags which have B and B_2.

When using the top-to-bottom connections the same scheme is carried out. In changing from series to 2-parallel the short jumper is cut. When odd grouping is used be sure to pick up the groups as indicated in the unequal coil grouping charts.

By Following the Tables It Is Easy to Change from a Star to a Delta Connection.—If it is desired to change from a star to a delta connection or the reverse, simply follow the tables. As an example, on the series star connection for a 4-pole, 3-phase motor, connected top-to-bottom, (Fig. 31) a star (*) is shown for the top lead in groups 2, 4 and 6. In Table 8, for the delta connections a C is shown for the top connection in group 2. For the top connection in group 4 is a B and for the top connection in group 6 is A. These are the only places in which the series delta connection (Fig. 36) differs from the series star connection (Fig. 31). Then to change the connection from series star to series delta, we connect the top of group 6 to an A lead, the top of group 2 to a C lead, and the top of group 4 to a B lead. This can be done by cutting open the star leads at the star point and splicing on enough wire to make the connections to the proper leads.

These diagrams and connection tables can be used with either a long or short type of jumper regardless of how the leads, stars, etc., are brought out and independently of the direction in which the winding proceeds. For example, suppose we have a 6-pole, 3-phase, series star-connected motor (Fig. 46) with top-to-top jumpers which we want to change to 2-parallel star. First we consult Table 11 for 6-pole, 3-phase star with top-to-

top connections. Finding the *2-Parallel* line in this table, we start at any lead and pass through three groups of the *same phase*, *A*-1, 5-1, 5-*. The end of the third group (No. 7) in this same phase will be a star point, and the beginning of the fourth group in the same phase (No. 10) *A*-11, will be a line lead (*A*). Therefore, it is necessary only to take any lead to start with and check through three groups of the *same phase*. Then cut the jumper between the third and the fourth groups of this same phase. Bend the end of the jumper attached to the third group in towards the center of the stator, then with a piece of string or tie wire, tie the other part of the jumper to the original lead upon which we started. This ties the original lead to the beginning of the fourth group. After this is done for one phase, repeat the same process for the other two phases. Then connect together the three leads which have been bent in towards the middle and these will form the second star connection. It is not necessary to connect both of these star points together. To complete the operation the line leads are then attached to the other halves of the jumpers to which they were tied by the tie wires or strings.

This method can be applied to any connection. It would be time well spent to follow each connection in the diagrams and tables to see where and how the break is made from one connection to another.

There is another way to go about changing a 6-pole, 3-phase, series star connected motor with top-to-top jumpers to a 2-parallel star connection which uses Fig. 47 in connection with Table 11. First find the 2-parallel line in the table and start with any line lead. Then refer to Fig. 47 and trace through three groups in the same phase. Since this is a 6-pole machine there will be six groups per phase connected together for the series connection. For the 2-parallel connection there will be three groups in series per leg and two legs per phase. Suppose we start with the *A* line lead of group 1 (Fig. 47) and pass through three groups of this phase (*A*-1, 5-1, and 5-*) which are groups 1, 4 and 7 of Fig. 47. The fourth group of this same phase will be group 10 marked 11-*A*. Thus it will be seen that the end of the third group of this same phase is a star (*) point. The beginning of the fourth group (No. 10) will be the start of the parallel leg of this same phase and is therefore connected to line lead *A*, as explained in the first method that referred to the table of connections.

To make the change to 2-parallel, trace through the third group of the same phase and cut open the jumper between the third and fourth groups of the same phase. Make the end of the third group a star point and connect the beginning of the fourth group of this same phase (No. 10) to the line lead first started on which in this case is line lead *A*. This will parallel one phase. The other two phases can be cut over in the same way.

Things to Watch for a Delta Connection.—A delta connection is the one that is likely to trip the beginner, therefore, a few more words upon

it may be valuable. Suppose that we have a 2-parallel, delta, 6-pole, top-to-top connection and we want to reconnect it to series delta. In the 2-parallel connection each line lead will have four taps connected to it, two top jumpers and two bottom jumpers. For the purpose of this discussion we may consider that all the top leads are incoming leads. The bottom leads could be chosen if desired, but in this case we shall take the top leads. If the top leads are chosen they must be kept as incoming jumpers throughout the job. Considering the top leads as the incoming leads take any one line and cut off the bottom leads attached to it. Do likewise to the remaining two line leads. After this is done there will be six bottom leads projecting from six groups. Then take the first bottom lead to the right and calling this group No. 1 count over to group No. 4. Join these two groups together. This will leave four leads. Take the next group to the right and calling this No. 1 count over to group No. 4 and connect the bottom leads of these two groups together. The remaining two leads are then connected together. To check the connections start at any one line lead and follow the winding through each phase. Then if the connection is correct, the three phases will have been passed through and the end of the operation will bring us to the line lead upon which the start was made.

General Rules for Reconnecting 3-phase Motors.—The following general rules for reconnecting 3-phase motors should be remembered. Pole-phase groups 1 and 4 apart, belong to the same phase but are of opposite polarity. If we enter group No. 1 on a top lead we must enter group No. 4 on a bottom lead. Likewise, pole-phase groups 1 and 7 apart belong to the same phase and have the same polarity. In this case if we enter group No. 1 on a top lead we must enter group No. 7 on a top lead. The method of representing a group of coils by a straight line in the diagram, and assigning a number to each such pole-phase group, makes the diagrams applicable to all windings having the same number of poles and phases regardless of the number of coils per group and the coil pitch or throw.

Then by adding a letter or star and number to the beginning and ending of each group, it is a simple matter for unskilled help to connect up motors in the shop by the use of tags as described on page 3.

All the diagrams in this book are standardized. That is, each diagram starts at group No. 1 and the group numbers proceed around the diagram in a clockwise direction. Also, the current direction is assumed to be flowing from left to right in group No. 1 in all the diagrams.

The numbering and lettering system of marking these connecting diagrams has the following added advantages. A table has been made up for each type of diagram; that is, top-to-top and top-to-bottom. These tables give the letters and numbers for each group. Then repair men can make up a memorandum book with the lettering for one diagram

per page. In this way they will always have connecting data on hand as it is a simple matter to make up a rough diagram from the tables if one is found necessary. Memorandum books of these connecting tables will be found to be mighty handy and are well worth the time spent in writing them up.

These tables also come in handy when a trouble man calls up and wants data on reconnecting a motor. Just read the lettering and numbers off to him over the phone. He can jot these down and will be able to proceed, thus saving considerable time and in some cases, an unnecessary trip back to the shop for instructions.

CHAPTER II

HOW TO USE THE COIL GROUPING CHARTS AND TABLES

Number of Coils Required in Each Group.—In connecting an induction motor, the winding must first be connected into pole-phase groups. Therefore, the operation that will be dealt with in this chapter will be how to determine the number of coils which must be in each group. The methods of connecting the groups together have been explained in Chapter I. The number of coils which should be connected together in each group is given in the *Main Table* (pages 8–9) and in the other tables which are designated as *Chart A*, *Chart B*, *Chart C*, etc. The *Main Table* gives directly the number of coils in each group if the winding is an "equal" winding. Throughout this discussion the term "equal" winding will mean that all of the coil-groups have the same number of coils. If the winding is an "unequal" winding (that is all the groups do not have the same number of coils) this fact will be indicated by a letter in the *Main Table* which will refer to one of the charts as *A*, *B* etc.

How to Use the Main Table.—The first thing to do in any case is to consult the *Main Table*. The columns in this table are arranged under the general heading of *Number of Coils in Machine*. The top row of figures refers to this heading and it should be remembered that the number of coils in the machine, and not the number of slots, is designated. Under each figure, representing the number of coils, a sub-division is made according to whether the machine is 2-phase or 3-phase. This is indicated by the figures 2 and 3 in the second line of the *Main Table*. In the left-hand column of the table will be found the figures referring to the number of poles in a machine. And the second column will show the type of connection such as series, 2-parallel, etc.

We can best explain the method of finding the number of coils per group by using an example. Suppose, for instance, that we have a motor with thirty-six coils and we want to connect it for 6 poles, 2-phase with a 2-parallel connection. Then, we look under the figure 36 in the top line of the *Main Table* and in the left-hand column under this figure, since the left-hand column is for a 2-phase connection. In this column to the right of the figure 6, which indicates 6 poles, and the 2-parallel connection, we find that there is a figure 3. This figure 3 is seven lines down in the body of the table and seven lines over to the right. This figure indicates that all of the groups must have three coils. This is an equal winding.

Main Table—Number of Coils

This table gives the number of coils in each group for windings having equal groups, that is, the same number of coils in each group. Each letter in this table indicates where equal groupings are not possible and that the unequal grouping will be found in other tables identified by those letters. A small (k) in this Main Table indicates that a coil must be killed in each group when this letter appears in this table. If this small (k) does not appear in this Main Table for the particular connection then no

No. of poles	Connection	No. of coils: 12	18	24	36	48	54	60	62	72	80	84	86	90	96
	Phases	2 | 3	2 | 3	2 | 3	2 | 3	2 | 3	2 | 3	2 | 3	2 | 3	2 | 3	2 | 3	2 | 3	2 | 3	2 | 3	2 | 3
2	Series	3 | 2	A | 3	6 | 4	9 | 6	12 | 8	A | 9	15 | 10	A | B	14 | 12	20 |	21 | 14	|	| 15	24 | 16
	2-parallel														
4	Series	C | 1	D	3 | 2	C | 3	6 | 4	C | D	C | 5	C | D	9 | 6	10 | D	C | 7	C | D	C | D	12 | S
	2-parallel														
	4-parallel														
6	Series	1 |	E | 1	2 | F	3 | 2	4 | F	E | 3	5 | F	E | F	6 | 4	E | F	7 | F	E | F	E | 5	8 | F
	3-parallel														
	6-parallel														
8	Series			G | 1	G | H	3 | 2	G | H	G | H	G | H	G | 3	5 | H	G | H	G | H	G | H	6 | 4
	2-parallel														
	4-parallel														
	8-parallel														
10	Series					K | L	K | L	3 | 2	K | L	K | L	4 | L	K | L	K | L	K | 3	K | L
	2-parallel														
	5-parallel							3 | 2							
	10-parallel														
12	Series			1	M | 1	2 | N	M | N	M | N	M | N	3 | 2	M | N	M | N	M | N	M | N	4 | N
	2-parallel														
	3-parallel														
	4-parallel					N									
	6-parallel				M			M	N			M	M	N	
	12-parallel														
14	Series				P	P | X	P | X	P | X	P | X	P | X	P | X	3 | 2	P | X	P | X	P | X
	2-parallel														
	7-parallel														
	14-parallel														
16	Series					R | 1	R | Y	R | Y	R | Y	R | Y	R | Y	R | Y	R | Y	R | Y	3 | 2
	2-parallel														
	4-parallel														
	8-parallel														
	16-parallel														
18	Series				1	S	S | 1	S | Z	S | Z	2 | Z	S | Z	S | Z	S | Z	S | Z	S | Z
	2-parallel														
	3-parallel														
	6-parallel														
	9-parallel														
	18-parallel														
20	Series					T	T |	T | 1	T | J	T | J	2 | J	T | J	T | J	T | J	T | J
	2-parallel														
	4-parallel														
	5-parallel														
	10-parallel														
	20-parallel														
22	Series						V |	V |	V |	V | U	V | U	V | U	V | U	V | U
	2-parallel														
	11-parallel														
	22-parallel														
24	Series					1	W	W	W	W | 1	W | O	W | O	W | O	W | O	2 | O
	2-parallel														
	3-parallel														
	4-parallel														
	6-parallel							W							
	8-parallel														
	12-parallel														
	24-parallel														
No. coils		12	18	24	36	48	54	60	62	72	80	84	86	90	96

Per Group in a Winding

coil is killed even though the (k) is present in other tables. An asterisk (*) in this Main Table means that when consulting other tables which are referred to in this Main Table, the proper grouping will be found in the line in which an asterisk appears in conjunction with the figure which indicates the total number of coils. A blank space in this Main Table indicates that there is no practical grouping which can be made with the given number of coils and poles.

| in machine | | |

Suppose now, we have the same winding with thirty-six coils and want to connect it for 8 poles, 2-phase in 2-parallel connection. Reading down the same column as before, and over to the right from the poles and 2-parallel designations, we find the letter *G*. When we find a letter such as this, we know that the grouping will be unequal and that we must consult the chart designated by the letter in order to find out how to arrange the groupings. In this case, we consult *Chart G*. In this chart the column at the left refers to the number of coils in the winding while the figures in the body of the table tell the number of coils in each group. Thus we see that in the first group there are three coils, in the second group two coils, in the third group two coils, in the fourth group two coils, in the fifth group two coils, and so on. This is the way that the coils should be connected in groups. It will be noticed that in some of the groups a small letter *k* appears above and to the right of the figure indicating the number of coils. This letter *k* may be disregarded unless a similar letter *k* appears also in the *Main Table* for the particular winding in question. As it does not appear for the 8-pole, 2-parallel winding it is disregarded in this case, and the figures given in *Chart G* are followed instead.

However, if this had been a 4-parallel winding, leaving all other conditions the same, it will be seen by consulting the *Main Table* that a small *k* appears with the letter *G*, as *Gk*. Therefore, this small *k* must be taken into account when grouping the coils according to *Chart G*. In each group where this small *k* appears one coil must be killed. This means that in groups 1, 6, 9 and 14 a coil must be killed leaving only two coils in each of the groups.

In some cases the charts show a notation such as 3-1. This means that one coil must always be killed in such a group. A case of this kind is shown in *Chart H* in the left-hand table for the winding having sixty-two coils. The grouping according to this line of figures is as follows: 3, 3-1, 3, 2, 3, and so on. This means that the second group which is designated by 3-1 must be of three coils, one of which is killed.

In a few cases a star or asterisk (*) is shown in the *Main Table*. In this case, in the chart referred to by the letter in the *Main Table*, there are two rows of figures applying to the same number of coils. The second row of figures has at the left-hand end a star. This is the row of figures which must be used when the star appears in the *Main Table*. Where such a case occurs it means that a series connection may be used with this number of coils without killing any coils. However, when a parallel connection is wanted some of the coils must be killed and the method of doing this is indicated by the line in the chart in which the star appears.

As an example take a 2-phase, 6-pole motor having eighteen coils. For a series connection the *Main Table* has the notation *E*. For a 2-parallel connection the notation is E.* Looking under *Chart E* we see

there are two lines for eighteen coils. One of the lines has an asterisk with the 18 as 18.* This is the line to use when making repairs on 2-parallel windings.

Although the charts cover most of the cases met in ordinary repair work, it is well to explain how to figure out the unequal coil groupings for any case. The method of doing this is explained in Chapter III.

The coil grouping charts and tables consist of one *Main Table* and twenty-four sub-charts as A, B, C, etc. These subcharts are placed in each chapter according to pole and phase. The *Main Table* carries an index at the front of this book, giving the page number for each sub-chart. Each sub-chart is divided into two sections; one for top-to-top diagrams, and the other section for top-to-bottom diagrams, up to and including the 12-pole. From 14 to 24 poles only the top-to-topcharts and diagrams are used.

The *Main Table* can also be used when changing the number of poles or phases in a motor as it will show whether the new grouping will be equal or unequal and also the connections possible.

The sub-charts are laid out according to the group numbers used on the diagrams and for accurate results the winding should be laid out and connected up as given in the charts and diagrams. Care should be taken to use the proper chart and diagram; that is, top-to-top chart and diagram or top-to-bottom chart and diagram. The sub-charts will be found in each chapter according to pole and phase; that is *Charts A* and *B* will be located in the 2-pole chapter, *Chart M* in the 12-pole, 2-phase section, etc.

CHAPTER III

HOW TO WORK OUT UNEQUAL COIL GROUPINGS

Arranging unequal groupings of coils in induction motors may look like a problem in higher mathematics to those who have not had it explained to them, but it is not as difficult as it appears. The rules given in this chapter are made up so that they will be easy to follow. They give just the information that is needed to handle a winding job that may not be covered in the tables.

It is not difficult to determine the proper grouping of coils for any induction motor when the details of the method to use are understood. These details and some of the ways of figuring out groupings are explained in the following paragraphs. Of course the majority of windings are covered by the *Main Table* and the *Winding Diagrams*. But for those cases that are not covered in the tables and charts, these general instructions will be useful.

Any winding will fall in one of the four methods of grouping:

(1) Equal grouping.
(2) Equal grouping with some dead coils.
(3) Unequal grouping.
(4) Unequal grouping with some dead coils.

There is also a fifth possibility, which is, that the particular winding is not practicable with the given number of coils. The rules and examples will show in which of these classes any winding belongs and will explain how to make the various arrangements of coils in groups.

Arranging Unequal Groups of Coils.—A correct arrangement of unequal groups of coils can be worked out in several ways. One method is by following an arrangement similar to that shown in the accompanying winding diagrams. The table on page 17 will help in this method. Another method is to lay out the groups on paper and thus determine the best arrangement. A third plan makes use of the inner circles on the diagrams as shown in the winding diagrams for 14 poles and over. All of these methods are explained in the following paragraphs.

Method No. 1.—For the first method, suppose as an example, we have a 12-pole, 3-phase winding with ninety coils, as in the example for Rule II—(*a*) on page 16. There are thirty-six groups in this winding (12 poles $\times$ 3 phases = 36). Now, dividing the 90 coils by 36, we have $90 \div 36 =$ 2 and a remainder of 18. This means that eighteen groups will have an extra coil apiece, or $2 + 1 = 3$ coils. The other groups, $36 - 18 = 18$,

will have two coils apiece. Therefore there are eighteen large groups and eighteen small groups. Now in the table on page 17 consult the section for 12 poles and 3 phases. For windings having more than 14 poles, the information is included in the various tables for unequal grouping and not in the table on page 17. At the extreme right end of each table the numbers of large groups and small groups are given. This conforms to the method as used in Fig. 1 (see page 43). We see in the fifth column of table on page 17 opposite 18 and 18, the figure 54. The 54-coil winding also has eighteen large groups and eighteen small groups and should be used as a guide. It will be found in *Chart N*.

Method No. 2.—The second method may be followed where no guide can be found in the table on page 17. In this method the groups are set down on paper, as shown in the table on page 18. Cross-section paper is the best to use. The particular winding shown in the table on page 18 has twenty-four coils and it is desired to connect them for 6-poles, 3-phase series, star or delta.

There are eighteen groups in this winding ($6 \times 3 = 18$). Numbers corresponding to these groups are put down in the first line. Underneath, in line two, are placed letters *A*, *B* and *C* to show the phase of the groups. Now there are twenty-four coils and eighteen groups, and dividing 24 by 18 we get a quotient of 1 and a remainder of 6. Therefore, there are six large groups with two coils each and twelve small groups with one coil each. Now with eighteen groups total and six large groups, we get a pitch of 1 and 4 for the large groups ($18 \div 6 = 3$), which gives a pitch of 1 and 4. In line three of the table on page 18 the cross marks (*X*) show the location of the large groups spaced 1 and 4. In this case it happens that all the groups would fall in the *A* phase if placed in this way. They must, however, be distributed equally among the three phases. To do this we can let the first one remain in the *A* phase as shown in line four of the table on page 18. The next large group must be placed in another phase. Usually it is better to place the second one in the *C* phase. This is done in line four. It is placed in the *C* phase of the same pole in which it was placed in line three. The next large group is now placed in the *B* phase. This is repeated until the end of the winding is reached. The grouping is then as shown in the bottom line.

This grouping holds for a top-to-top winding but it will not always hold for top-to-bottom connections. For top-to-bottom connections we divide the top-to-top winding into poles, numbering them from first to last: 1, 2, 3, 4, 5, 6, etc. Then we move these poles into the following order: 1, last; 2, next-to-last; 3, second-from-last; 4, third-from-last, and so on.

In this way for a 6-pole winding the top-to-bottom connection will have the original poles arranged in the following order: 1, 6, 2, 5, 3, 4.

Therefore, the top-to-bottom groupings for the winding shown in the table on page 18 is: 211, 121, 112, 112, 121, 211.

These figures must always be checked *to see that every circuit has the same number of coils and that every phase has the same number.* There may be some cases in which this method will not give a correct connection. It must be remembered in using the 3-phase connection diagrams and tables in this book, that the start of the *B* phase is in the last pole. This phase then passes to the first pole for top-to-top connections. For top-to-bottom connections it passes to the second pole. The *A* and *C* phases start in the first pole.

Method No. 3.—The third method of locating the large groups uses the inner circles shown in the diagrams for 14 to 24 poles. Similar circles might be drawn in any of the other diagrams. As an example of the method of using these circles, suppose we have a 14-pole, 3-phase winding having forty-eight coils. To find the number of large groups divide the number of coils by the number of groups. Dividing 48 by 42 we get 1 and a remainder of 6. Then we have six large groups of two coils each. To locate these properly we draw an inner circle as shown in Fig. 139. Then for convenience divide this into parts as shown 10 deg. apart starting with 0 in the center of group No. 1. Now we have six large groups and there are 360 deg. in the circle. Therefore the large groups should be sixty deg. apart ($360 \div 6 = 60$). Therefore they will be located at 0, 60, 120, 180, 240 and 300 deg. These points correspond with groups 1, 8, 15, 22, 29 and 36. These groups are respectively in the following phases: *A*, *B*, *C*, *A*, *B*, *C*. Two of them are in each phase, and these can be made the large groups.

If the points had all fallen in the same phase it would have been necessary to shift some of them so that the large groups would be in the order of phases *A*, *C* and *B* or phases *A*, *B* and *C*.

RULES FOR WORKING OUT VARIOUS ARRANGEMENTS OF COILS IN GROUPS

Rule I. Divide the Number of Coils by the Number of Groups.—The number of groups equals the number of poles multiplied by the number of phases.

(*a*) If this division gives a whole number as quotient, then the groups will all be equal, and have the number of coils represented by this whole number.

(*b*) If this division does not come out even, pass to Rule II.

Rule II. Divide the Number of Coils by the Number of Circuits.—The number of circuits equals the number of phases multiplied by the number of parallel paths. For instance, a 3-phase, 2-parallel winding has six circuits.

(*a*) If the quotient of this division is a whole number, no coils need be killed. Then pass to Rule III.

(*b*) If the division leaves a remainder, then coils must be killed equal in number to the remainder. Suppose, for instance, there are eight circuits and ninety coils. Then $90 \div 8 = 11$ and a remainder of 2. This means two coils must be killed. If the number of killed coils exceeds eight per cent of all the coils, the winding should not be used to carry its normal rated load in horsepower. The number of turns per slot should be increased, if possible, without reducing the wire size.

In killing coils, the coils to be killed should be chosen at points as nearly equidistant from each other as possible around the stator. At the same time the dead coils must be as equally distributed as possible among the different phases. After the coils have been killed, the winding is treated as a winding in which no coils are killed. The number of coils now is equal to the number of active coils (the total number minus the number killed). Then pass to Rule III.

Rule III. Divide the Number of Active Coils by the Number of Groups.—(*a*) If the quotient comes out a whole number then each group will have that many active coils.

(*b*) If there is a remainder left after the division, the grouping will be unequal. Pass to Rule IV.

Rule IV. On Dividing the Number of Active Coils by the Number of Groups, There Will Be a Quotient and a Remainder.—For instance, dividing ninety coils by twenty-four groups we get $90 \div 24 = 3$ (the quotient) plus a remainder of 18. Then in this case eighteen of the groups will each have three (the quotient) + 1, or 4, coils; and the other groups ($24 - 18 = 6$ groups) will have three coils each.

These groups must be arranged so that each phase has the same number of active coils; also so that the larger groups are distributed as evenly as possible around the winding. Different methods of getting a good arrangement are explained further by means of examples.

SOME EXAMPLES SHOWING HOW TO GROUP THE COILS

In the following paragraphs are given some examples which will explain clearly the Rules I to IV.

Example for Rule I.—(*a*) Suppose we have a winding with ninety coils and want to connect it for a 3-phase, 6-pole series winding. According to Rule I the first thing to do is to divide the number of coils by the number of groups. The number of groups in this case is 3×6 or 18. Dividing ninety coils by eighteen groups we get an answer of five without any remainder. In this case, then, the groups will all have five coils each.

Example for Rule I.—(*b*) Suppose now we have a winding with ninety coils and we want to get a 12-pole, 3-phase, 2-parallel connection.

According to Rule I, we divide the number of coils by the number of groups. The number of groups in this case equals 3 × 12 or 36. Dividing 90 by 36 we get a remainder and, therefore, according to (*b*) of Rule I we must pass on to Rule II. This remainder means that coils must be killed or that we must use an unequal grouping.

Example for Rule II.—(*a*) We now take the winding of ninety coils, mentioned in the last paragraph, and divide the number of coils by the number of circuits. The number of circuits equals the number of phases multiplied by the number of parallel paths, which in this case equals three phases multiplied by two parallel paths. This amounts to six circuits. Dividing 90 by 6 we get 15 without any remainder, and, therefore, according to (*a*) of Rule II, no coils need be killed. Consequently, according to (*a*) of Rule II we pass on to Rule III.

Following Rule III, when we divide the number of coils by the number of groups we find that we have a remainder. With 12 poles and three phases, we have thirty-six groups, and dividing 90 by 36, we get an answer of 2 plus a remainder of 18. This means that eighteen of the groups will each have 2 plus 1, or three coils. Then the remainder of the groups, which equals 36 minus 18, or eighteen groups, will each have two coils. The method of arranging the large coils is explained in the paragraph following the example for Rule III—(*b*).

Example for Rule II.—(*b*) Suppose now we have a winding with sixty-two coils and want to get a 10-pole, 3-phase, 2-parallel winding. According to Rule II we divide the number of coils by the number of circuits. There are six circuits (3 phases × 2 parallel). Dividing 62 by 6 we get a remainder of 2. Then two coils must be killed. We can kill one coil in the *A* phase in group 1. The next coil should be killed about half-way around the winding, or in group 16, as there are thirty groups. This coil should be in either the *B* or *C* phase. If three coils had to be killed they would be spaced one-third way around in *A*, *B* and *C* phases. Four dead coils would be one-fourth way around, and so on.

Now suppose it is desired to connect this 62-coil winding for an 8-pole, 3-phase, 8-parallel winding. According to Rule II we divide the number of coils, 62, by the number of circuits. The number of circuits equals 3 × 8 or 24. Dividing 62 by 24 we get a remainder of 14. This means that fourteen coils would be killed. This is twenty-three per cent of the total number of coils, but not over eight per cent should be killed, according to Rule II—(*b*). Therefore, such a connection is not practicable.

Example for Rule III.—(*a*) Suppose we have the 62-coil winding and want to connect it for 10-poles, 3-phase, 2-parallel.

After killing the two coils according to Rule II—(*b*) we now have sixty active coils. Following Rule III, we divide the number of coils by the number of groups. Then 60 ÷ 30 = 2, and there is no remainder.

For Locating Large Groups in Unequal Groupings

This table shows how various combinations of large and small groups are placed. It refers to the Charts in which groupings may be found similar to most cases which will occur. The number of large groups equals the remainder left after dividing the total number of coils by the total number of groups.

For 16 to 24 poles the numbers showing the proportion of large to small groups are included in the charts showing unequal coil groupings.

No. of poles	No. of phases	No. of large groups	No. of small groups	Like winding with No. of coils shown below	Refer to chart
2	2	2	2	18	A
	3	2	4	62	B
4	2	2	6	90	C
		4	4	12	
		6	2	54	
		7	1	135	
	3	2	10	62	D
		3	9	135	
		4	8	160	
		6	6	18	
		8	4	80	
6	2	2	10	62	E
		3	9	135	
		4	8	104	
		6	6	18	
		8	4	80	
	3	2	16	128	F
		6	12	24	
		8	10	62	
		9	9	135	
		12	6	48	
		14	4	86	
		16	2	160	
8	2	4	12	36	G
		6	10	54	
		7	9	135	
		8	8	24	
		10	6	90	
		12	4	60	
		14	2	62	
8	3	6	18	54	H
		8	16	80	
		12	12	36	
		14	10	62	
		15	9	135	
		16	8	160	
10	2	2	18	62	K
		4	16	84	
		6	14	86	
		8	12	48	
		10	10	90	
		12	8	72	
		14	6	54	
		15	5	35	
		16	4	96	
10	3	2	28	62	L
		6	24	96	
		8	22	128	
		10	20	160	
		12	18	72	
		14	16	104	
		15	15	135	
		18	12	48	
		20	10	80	
		24	6	54	
		26	4	86	
12	2	6	18	54	M
		8	16	80	
		9	15	135	
		10	14	62	
		12	12	36	
		14	10	80	
		16	8	160	
		18	6	90	
12	3	6	30	150	N
		8	28	80	
		12	24	48	
		14	22	86	
		16	20	160	
		18	18	54	
		20	16	128	
		24	12	168	
		26	10	62	
		27	9	135	
		32	4	104	
14	2	4	24	60	P
		6	22	62	
		8	20	36	
		10	18	150	
		12	16	96	
		16	12	72	
		20	8	48	
		23	5	135	
		24	4	80	
		26	2	54	
	3	2	40	86	Q
		6	36	48	
		9	33	135	
		18	30	54	
		18	24	60	
		20	22	62	
		24	18	108	
		30	12	72	
		34	8	160	
		36	6	120	
		38	4	80	

LOCATING UNEQUAL COIL GROUPINGS
This is a 6-pole 3-phase Winding with Twenty-four Coils

Group No	1 2 3	4 5 6	7 8 9	10 11 12	13 14 15	16 17 18
Phase	A B C	A B C	A B C	A B C	A B C	A B C
Large groups, pitch 1 and 4	X	X	X	X	X	X
Large groups, relocated	X	X	X	X	X	X
Phase after relocating	A	C	B	A	C	B
Grouping, top-to-top	2 1 1	1 1 2	1 2 1	2 1 1	1 1 2	1 2 1

Therefore, each group will have two active coils. Also there will be two dead coils, as discussed in the example for Rule II—(*b*).

Example for Rule III.—(*b*) Suppose now we have the 62-coil winding and want to connect it for 8-poles, 3-phase series. As shown under the example for Rule II—(*b*), we should kill two coils, leaving sixty active coils. Then, according to Rule III, we divide the number of coils by the number of groups. This gives 60 ÷ 24 = 2 and a remainder of 12. According to (*b*) of Rule III, this means that the grouping will be unequal, and we must pass to Rule IV.

Example for Rule IV.—Under Rule IV an example was given of finding the number of large coils in a winding. As another case we may take the winding just mentioned in the example for Rule III—(*b*). We find that in this 8-pole winding, when we divide the active coils by the number of groups, that we have a remainder of 12. This means that twelve of the twenty-four groups will be large groups having three coils each. The other twelve groups will have two coils each. Now the next job is to distribute the large groups in the proper way. See Methods 1, 2 and 3 on pages 12, 13, and 14.

CHAPTER IV

HOW TO LAY OUT AND CHECK UP 2-PHASE DIAGRAMS

It is the purpose of this chapter to tell how to lay out and to check up winding diagrams for lap wound induction motors. This description will cover the single-line diagram as used throughout this book. This simple diagram shows all the coils of one group by a single line. One single-line diagram will cover quite a number of different windings. One diagram may be used for any motor having a certain number of groups regardless of the number of coils per group and the pitch of the coils. This last information may be kept in a separate place.

Each of the heavy lines in these drawings represents one group of coils. It may be used to indicate any number of coils and the coil pitch may be whatever is desired. The number of coils per group and the coil pitch can be noted on a winding card. Where some groups have more coils than others, the grouping charts should be consulted and the arrangement noted on a winding card or diagram.

How Single-line Diagrams Are Drawn for Any Winding.—There are a number of points that should be understood in connection with constructing and checking single-line diagrams. Diagram A shows the steps in constructing a 2-phase 4-pole series diagram when using the top-to-top or short jumper. The first step is shown at *M*. This shows a circle divided into eight parts as there are eight pole-phase groups in the machine, or pole-phase groups or group lines equals number of poles times number of phases. After this is done then call any group No. 1 and number the rest consecutively clockwise as shown by the figures 1 to 8 of diagram *M*. Then start at group 1 and put direction arrows on the groups. In a 2-phase machine there will always be two adjacent groups having the same direction. The next two groups will have arrows in the opposite direction. As seen, groups 1 and 2 have arrows pointing to the right, while groups 3 and 4 have arrows pointing to the left. This is repeated throughout the circle. After this is done one end of group 1 is taken as the *A* lead. A letter *A* is put at this end of the group as shown. For convenience the left-hand side of each group is called the top lead and the right-hand side is called the bottom. Taking the top leads for the line leads, place the letter *A* at the left or top of group 1. Then the bottom lead of this group is connected by means of a jumper to the bottom lead of group 3, skipping one group. For convenience in drawing the jumpers several light circles (as in *M*) may be drawn in outside of the main

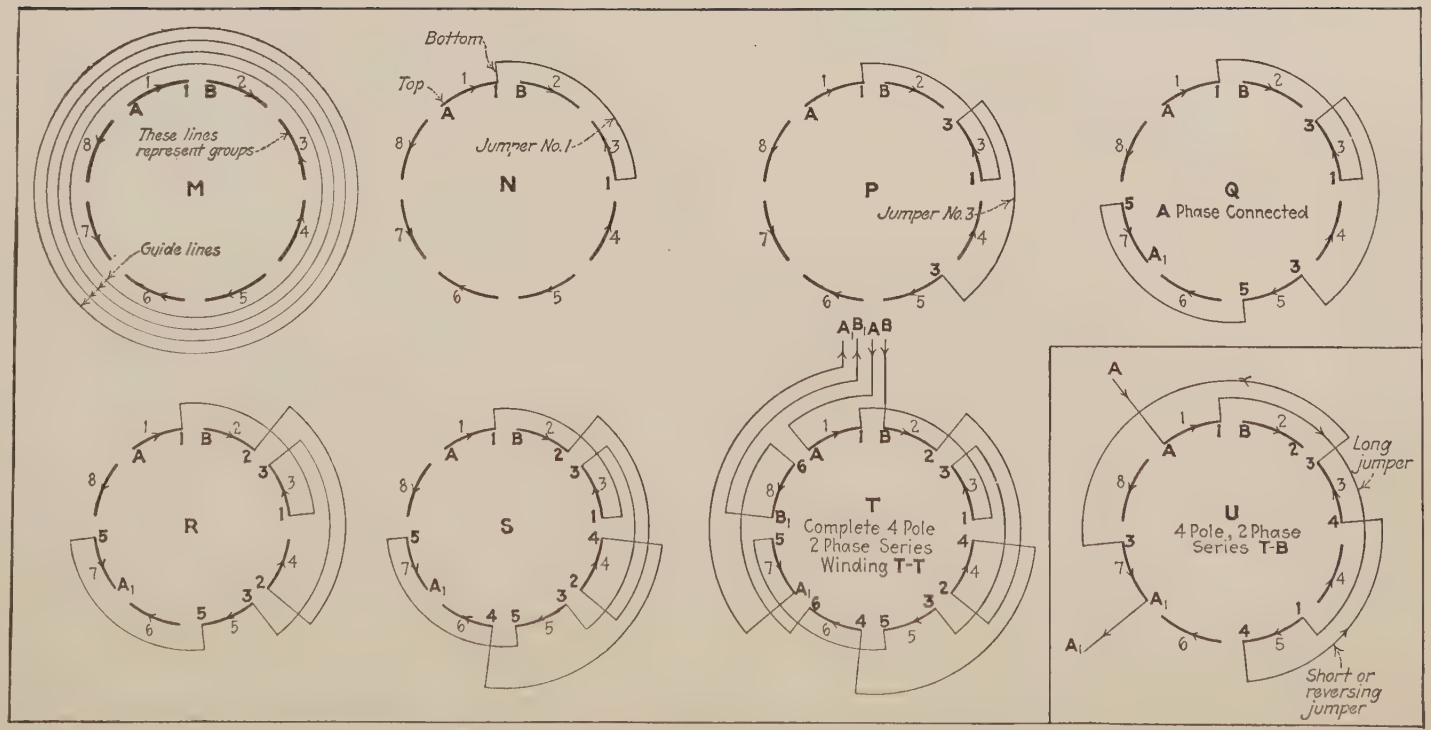


DIAGRAM A.—How a single-line diagram is constructed.

This is for a 4-pole, 2-phase motor. Drawings *M* to *T* show the steps in laying out a top-to-top or short-jumper connection. Drawing *U* shows one phase of a winding with top-to-bottom connections or long jumpers.

circle. Then the jumpers are drawn to follow these circles. The first jumper leading from group 1 is called No. 1 jumper and the bottom end of group 1 is marked with a figure 1. The other end of this jumper, which goes into the bottom of group 3, is also marked with figure 1 as shown in *N*. Then as in *P*, connect the top of group 3 with the top of group 5, again skipping one group. This jumper is called 3, and the figure 3 is put at the top end of the line representing group 3, and also at the top end of the line representing group 5.

At *Q* this process is carried one step further. A jumper is connected from the bottom end of group 5 to the bottom end of group 7. This jumper is called 5 and the figure 5 is placed at the bottom end of the lines representing groups 5 and 7. There are now four groups in series, which completes the *A*-phase.

At *R* the *B*-phase is started. The bottom side of group 2 is connected with the bottom of group 4 by means of jumper 2. This is continued at *S* by connecting the top of group 4 to the top of group 6, and this is carried forward further in *T* by connecting the bottom of group 6 to the bottom of group 8. This completes the *B*-phase. The line leads are then put in as shown at *T*.

To check this winding start at the *A* lead and follow through the groups that are two groups apart. These groups should be connected in such a manner that the arrows on alternate groups in the same phase reverse. The *B*-phase is then checked in the same way.

Connecting Jumpers in 2-phase Windings.—The diagrams just described have shown the short jumper or the top-to-top jumper. At *U* of Diagram A is shown the same winding connected up with the long jumper or the top-to-bottom jumper. In the latter winding all the north poles are first connected in series by means of long jumpers. Then from the end of this series of north-pole groups a short jumper connects to the series of south-pole groups. At *U* of Diagram A one phase of the top-to-bottom connection is shown.

To draw this kind of diagram connect *A* lead to the top of group 1. Then the bottom of group 1 is connected to the top of group 5, skipping over three groups. This is a general rule for a long jumper on a two-phase machine, that is, to skip over three groups or connect to groups 1 and 5. As this is a 4-pole machine there are two north poles and two south poles. Consequently as two north poles have now been covered, we must pass to the south poles. Therefore the bottom of group 5 is next connected to the bottom of group 3, thus connecting the series of two north poles to the beginning of the series of two south poles. This is a short jumper and in this case is reversing, that is, it passes back in the opposite direction to the direction in which the first long jumpers pass around the winding. Then the top of group 3 is connected to the bottom of group 7. The top lead of group 7 then forms the outgoing line lead, A_1.

This short jumper from group 5 could have connected to the bottom of group 7 if it had been desired. In this case the jumper would have been called "leading" instead of "reversing." With the leading jumper the top of group 7 would be connected to the bottom of group 3 and the top of group 3 would be the outgoing A_1 line lead.

Comparing Advantages of Short and Long Jumpers.—The short jumpers have certain advantages while the long jumpers have others. With the short jumpers (top-to-top connection) the coil leads themselves

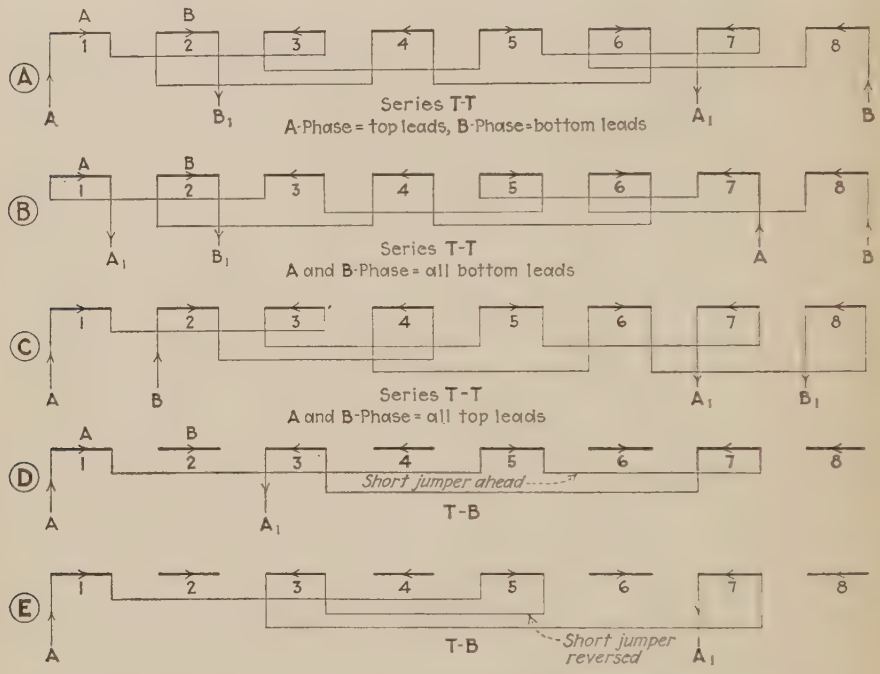


DIAGRAM B.—Line leads may be put on in several ways.

These drawings show how the lines may be connected to either top or bottom leads provided the polarity of the groups is kept correct. Also at *D* and *E* is shown the difference between placing the short jumper (on a top-to-bottom winding) ahead or reversed.

can be left long enough to serve as jumpers and thus eliminate the use of additional wire and a number of soldered joints. The short jumper makes a neater job as there are fewer cross-overs than with the long jumper. When unequal grouping is used the large groups can often be spaced more symmetrically if the short jumper is used.

The great advantage of the long jumper with parallel connections, is that it will compensate for unbalanced magnetic pull due to wear of bearings and other causes. One objection is the large number of cross-overs but this can be overcome by allowing the jumpers to stand up. With large machines this type of jumper is too long and cumbersome.

In all of the 2-phase diagrams shown so far the top leads have been used for line leads. However, it is immaterial whether the line leads are attached to the top leads of the groups or to the bottom leads provided the groups are connected in proper sequence and polarity. In Diagram B is another method of drawing the groups of 2-phase windings. Drawings *A* and *B* in Diagram B illustrate the difference between using top leads and using bottom leads, for the line connections. Both of these drawings show a 4-pole, 2-phase, series connection. In *A* the *A*-line leads are attached to top group leads and the *B*-phase line is attached to bottom group leads. It is found on application of the arrow check that the connection is correct. In *B* all of the lines connect to bottom leads and this connection is also correct. In *C* all of the line leads connect to top leads. These three diagrams all have short or top-to-top jumpers and all of the connections are different, but they are all correct as may be found by checking them with the arrows.

The next two drawings *D* and *E* show top-to-bottom long-jumper connections. At *D* the short jumper which connects the two series of poles is connected ahead from group 5 to group 7. At *E* the short jumper is connected reverse from group 5 to group 3 in the same manner as in *U* of Diagram A. Either one of these methods, *D* or *E*, is correct.

In all the preceding figures and all the diagrams in this book a letter or number is used at each end of the pole-phase groups. These numbers can be put on after the diagram has been all drawn in or as the diagram is being constructed step-by-step. In all the cases the lettering and numbering is used to enable an inexperienced winder to tag a stubbed winding and connect like numbers together.

How 2-parallel Connections Are Drawn.—After a series connection has been drawn it is an easy matter to figure out how 2-parallel connections should be made. A 2-parallel connection is one in which there are two circuits for each phase. The number of groups in series per circuit is equal to the total number of poles divided by two. In any parallel connection each circuit must contain an equal number of groups and an equal number of active coils. Never attempt to parallel the coils in any one group. This is because the coils are out of phase by the number of degrees between slots. At certain times the sides of coil 1 are in a stronger magnetic field than the sides of coil 2. Consequently there will be a higher voltage in coil 1 at these times which would cause a circulating current to flow between the two coils.

The proper way to parallel a winding is to put groups or series of groups in parallel with each other. Diagram C shows how a 2-parallel connection is made from a series connection on a 4-pole, 2-phase winding. Only one phase is shown here for the sake of clearness. At *M* and *N* is shown the change for a top-to-top connection or short jumper. At *P* and *Q* is shown the change for a top-to-bottom connection or long

jumper and at *R* is shown the 2-parallel connection called "right-and-left." At *M* the series connection is shown for the top-to-top diagram and below it is shown the 2-parallel connection. In the 2-parallel connection the heavy lines show where the changes in jumpers have been made. It will be seen that it is necessary only to open the jumper between groups 3 and 5, then the bottom of group 3 is connected to the A_1 line and the top of group 5 is connected to the *A* line. This is the

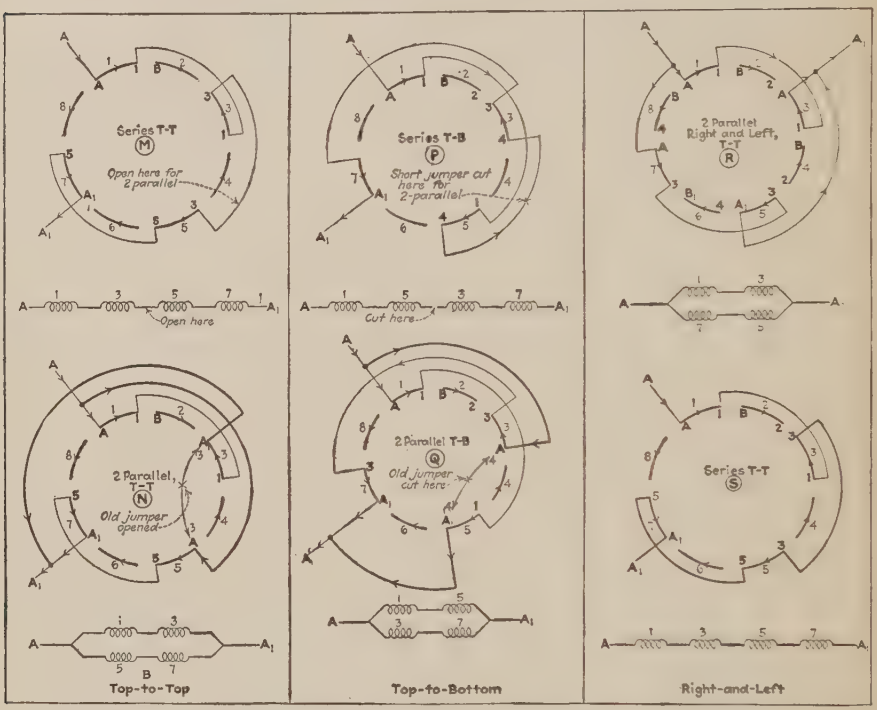


DIAGRAM C.—How 2-parallel windings are obtained from series connection.

These diagrams are all for 4-pole, 2-phase motors. The heavy lines show the leads which have been changed to get the connections given in the lower drawings. Diagrams M and N are for short jumpers and top-to-top connections. Diagrams P and Q are for long jumpers connected top-to-bottom. At *R* is a "right-and-left" 2-parallel connection, while *S* shows the changes necessary for a series connection. After the winding is checked up even a boy can make the connections.

easiest way to change from series to 2-parallel. All that is required is to cut the series of coils in half and connect the end of the first half to the outgoing lead and the beginning of the second half to the ingoing lead.

The connecting tables used in this book have been constructed on this principle and to show just where a change is necessary to make any desired reconnection.

At *Q* is a 2-parallel connection using the top-to-bottom or long jumper. This was made from the series connection at *P*. To get the

2-parallel connection the series of four coils is cut in half at the short jumper between groups 3 and 5. Then the bottom of group 3 is connected to the A line and the bottom of group 5 connects to the A_1 line.

There is another type of 2-parallel connection called the "right-and-left" connection. This is shown at R. Starting at the A lead the two parallel circuits pass respectively around the right-hand and the left-hand sides of the winding. One circuit starts at the top of group 1 and ends at the top of group 3. The second circuit starts on the *bottom* lead of group 7 and ends on the *bottom* of group 5. This type of connection is satisfactory for 2-parallel but it requires considerable time and labor to reconnect it for series. The series connection is shown in the lower diagram in S. In order to change the 2-parallel connection to series, the first step is to disconnect the A_1 line from groups 3 and 5. Next the A line is cut off from group 7. Jumper 3 is then disconnected from the top of group 7 and connected to the top of group 3. Then the bottoms of groups 5 and 7 are put together. Now the top of group 7 becomes the A_1 line lead. The B phase is reconnected in the same manner.

It is obvious that considerable more time is required to change this type of connection to series than is required to get a series connection from the 2-parallel windings shown at N and Q. For instance, to change the 2-parallel connections at N back to series it is necessary only to cut the top of groups 3 and 5 from their respective leads and connect these two groups together.

For these reasons the right-and-left type of parallel connection is not used to any great extent. The motor manufacturers try to use windings and connections which may be readily connected for two or more different voltages. This helps to reduce the stock of motors which must be carried in warehouses, etc. For example, a 440-volt motor may be designed for 440 volts with a series connection and carried in stock as a 220-volt motor connected 2-parallel. If there is a call for a 110-volt motor or a 440-volt motor, this machine can be reconnected in a very short time in 4-parallel for 110 volts or in series for 440 volts.

There are some 9-lead, 3-phase and 8-lead, 2-phase motors made which can be reconnected outside of the motor for two voltages. Diagrams of these connections are given in Chapter VII.

CHAPTER V

HOW TO LAY OUT AND CHECK UP 3-PHASE DIAGRAMS

This chapter gives details of methods for checking the windings of 3-phase induction motors and for constructing diagrams to be followed in stator windings. The explanations cover the short and long types of jumpers for series and parallel windings with both star and delta connections. The method for laying out the diagrams is explained for the simpler single-line type of diagram which shows only the groups of coils.

How to Construct a Single-line Diagram.—In constructing a single-line diagram, the first step is to draw the heavy single lines in a circle, as shown at *P* in Diagram H. There is one heavy line for each group in the winding. The next step is to put on the arrows showing the direction of current in the group. In constructing a 3-phase, single-line, diagram from the data, the arrows should be put on as shown in Diagram H at *M*. The arrows in this diagram alternate, first one arrow pointing in one direction, then the next in the opposite direction. The reason why the arrows should be put on in this manner will be explained in the following paragraphs.

How the Arrows Should Be Put on a Single-line Diagram.—Let us check the winding shown in Diagram D, for instance, by placing on arrows in the way they would be on a developed winding or the arrows on the line leads arranged with two pointing inward and one outward. With arrows placed in this way on a correct diagram, the arrows on the groups will alternate, the first three groups pointing in one direction, and the next three groups in the opposite direction. This check, however, is not always reliable when applied to single-line diagrams, as will be explained later, because sometimes the arrows in the groups may point in the correct direction and yet the winding may be incorrect. In Diagram D the arrows drawn in full lines show the correct method of checking the groups, while those drawn in dotted lines show the unreliable method. For the correct check as shown in Diagram D, the arrows point inward on all of the line leads. The arrows on the groups alternate first in one direction and then in the other entirely around the winding.

To prove that the "two in and one out" method of checking is not always reliable, let us examine Diagram F. This shows the unreliable check applied to a 4-pole, 3-phase, series-star diagram. This gives three cases of using this check. In each case, two of the arrows on the line

leads point inward, while one points outward. In *M* and *N* the arrows on the groups point in one direction on three groups and then in the opposite direction on the next three groups, and this is repeated around

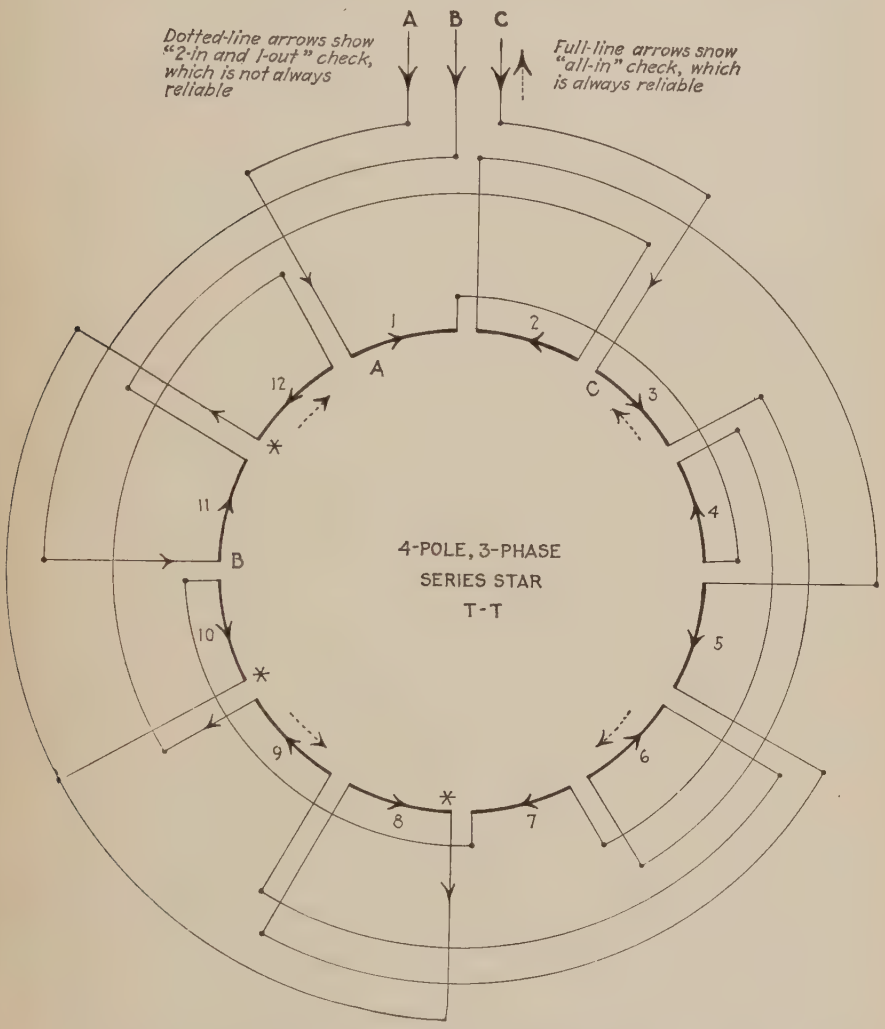


DIAGRAM D.—How to check single-line diagrams by means of arrows.

The most reliable way to check a single-line diagram is shown by the full arrows. These arrows on alternate groups reverse direction. This is possible only when the arrows on the leads *A*, *B* and *C* all point *inward* (or all outward). The dotted arrows show the direction of current. In this case the arrows on two leads (*A* and *B*) point inward while that on the *C* lead points outward. This latter arrangement of arrows will not always give a correct check as is demonstrated in Diagram *F*, page 29.

the diagram. According to the rule for this check, this would indicate that in both of these cases the diagram is correctly drawn. However, by a third application of the same check in *O* of Diagram F, it is found

that the arrows on the diagram alternate, first in one direction and then in the other. For this kind of a check, this shows that the connections are not correct. In the two cases of *M* and *N*, where the same check was applied, however, the mistake was not detected.

In applying the check shown in Diagram E, all of the line leads have the arrows pointing inward. Then, the current is traced through all of the groups and arrows put on them according to the direction of the

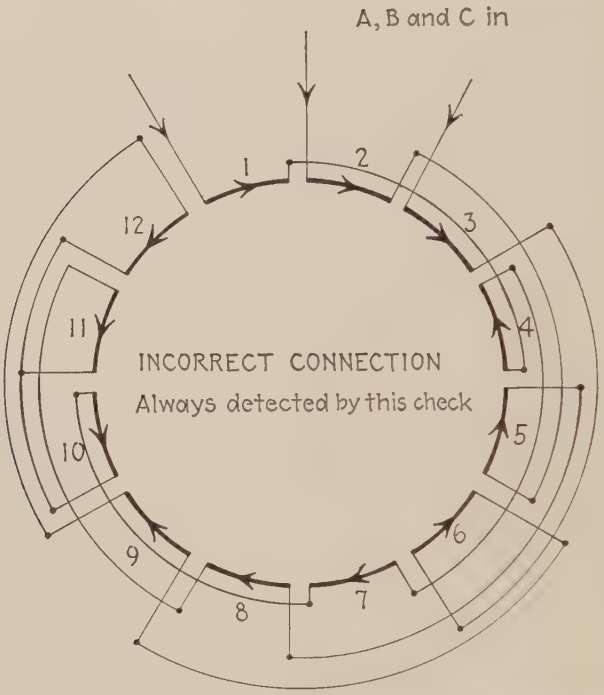


DIAGRAM E.—The "all in" check shown in this diagram will always detect an error in connections.

In the "all-in" check the arrows are placed pointing inward on all three leads. If the diagram is correct the arrows on the groups will alternate in direction. One group will point clockwise, the next group will point counter-clockwise, and this will be repeated throughout the winding. The check proves that the winding shown here is connected wrongly because there are three arrows on the groups in one direction. If the *B* phase were reversed the connection would be correct. The *B* lead should connect to the lower lead of group 11 and the star connection should go to group 2 on what is now the *B* lead.

current. Finally, if the arrows alternate, first in one direction and then in the other entirely around the windings, the connections are correct.

It is seen in Diagram E, however, that the arrows do not alternate in this way and, therefore, the diagram in Diagram E, which is the same as that in Diagram F, is not correct.

In Diagram G again is shown the reliability of the "all in" method of checking and the unreliability of the "two in and one out" method. The checks are applied in Diagram G to the long type of jumper, while

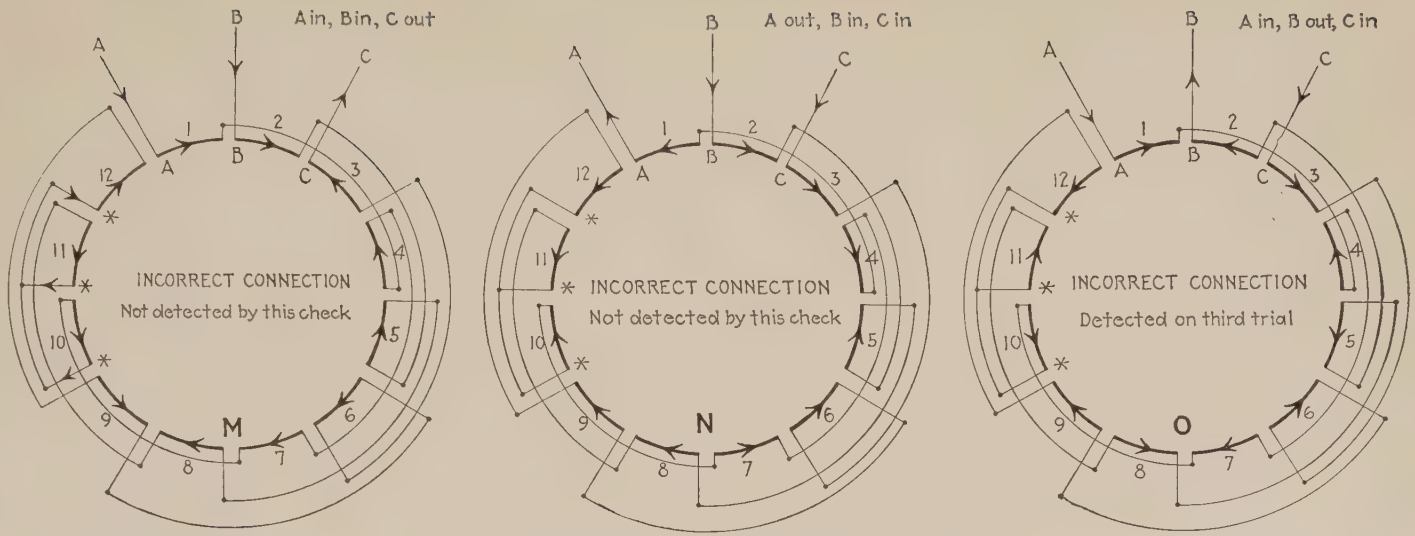


DIAGRAM F.—This kind of arrow check is not always reliable.

This diagram shows the check where the arrows on two leads are pointed in, while that on the other is pointed out. Now when this check is used the rule is that three adjacent groups will have arrows in one direction while the next three groups will have arrows pointing in the opposite direction. This is repeated around the diagram. But as shown, three checks of this kind must be made. The diagram is drawn incorrectly, as the wrong end of the *B* phase is connected to the line, yet the checks at *M* and *N* fail to disclose the error. The third check, at *O*, shows that the connection is incorrect. Instead of this kind of check it is safer always to use the check shown in Diagram E.

the diagrams shown in Diagrams E and F have the short type of jumper. All four of the diagrams shown in Diagram G are the same, and the connections are incorrect. By applying the checks in *M* and *N*, however, no error is detected. The "two in and one out" method does detect an error in *O*, but this might be the third trial, as it does not detect it in *M* and *N*. However, the "all in" check shown in *P* never fails to

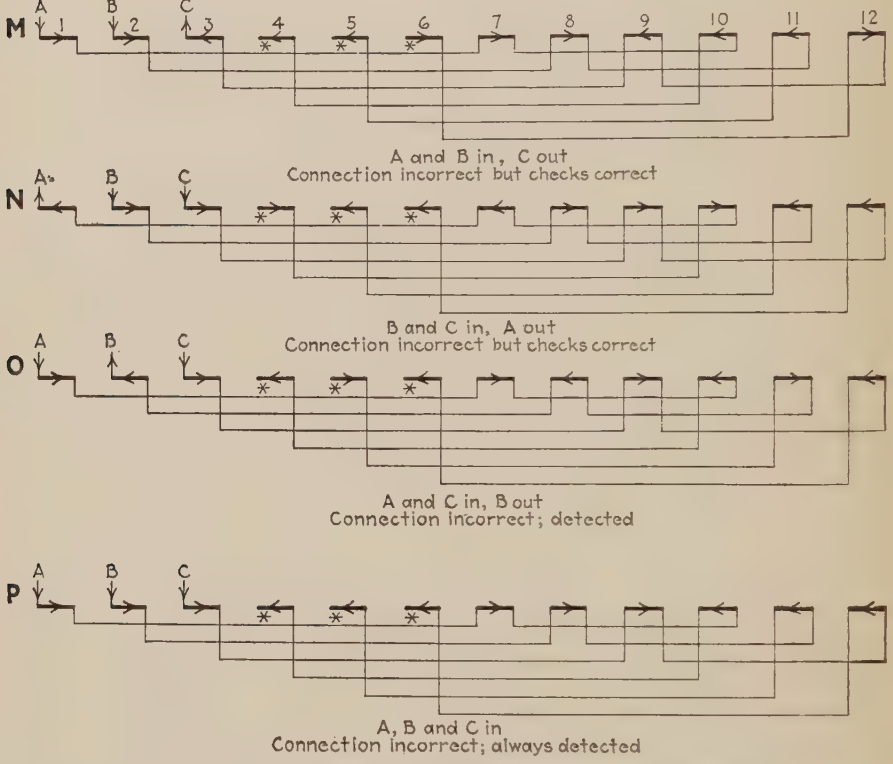


Diagram G.—The right and the wrong way to check windings.

This shows a long-jumper type of connection checked in the reliable way at *P* and the unreliable way at *M*, *N* and *O*. At *M*, *N* and *O* the arrows are put on the leads two inward and one outward. With arrows in these directions the arrows on the groups shown point first three in one direction, then three reversed, and so on. They do this in *M* and *N* even though the connections are wrong. The third check of this kind, at *O*, does show the mistake. The check shown at *P* detects the error at once. In this check all the arrows on the leads point in one direction. Then the arrows on the groups should alternate on alternate groups. They fail to do this in the diagram at *P*, therefore, this diagram is incorrect. Diagram E and Diagram F also illustrate the value of the "all-in" check.

detect the error. As seen in *P*, the arrows point, first, three in one direction and then three in the opposite direction, and this shows that the connection must be wrong. For this "all in" check, the arrows in the groups must alternate, the first arrow in one direction and the second arrow in other direction, and so on.

Therefore, in checking the single-line diagram, the arrows should be put on as shown in *M* of Diagram H, the arrows on the line leads all

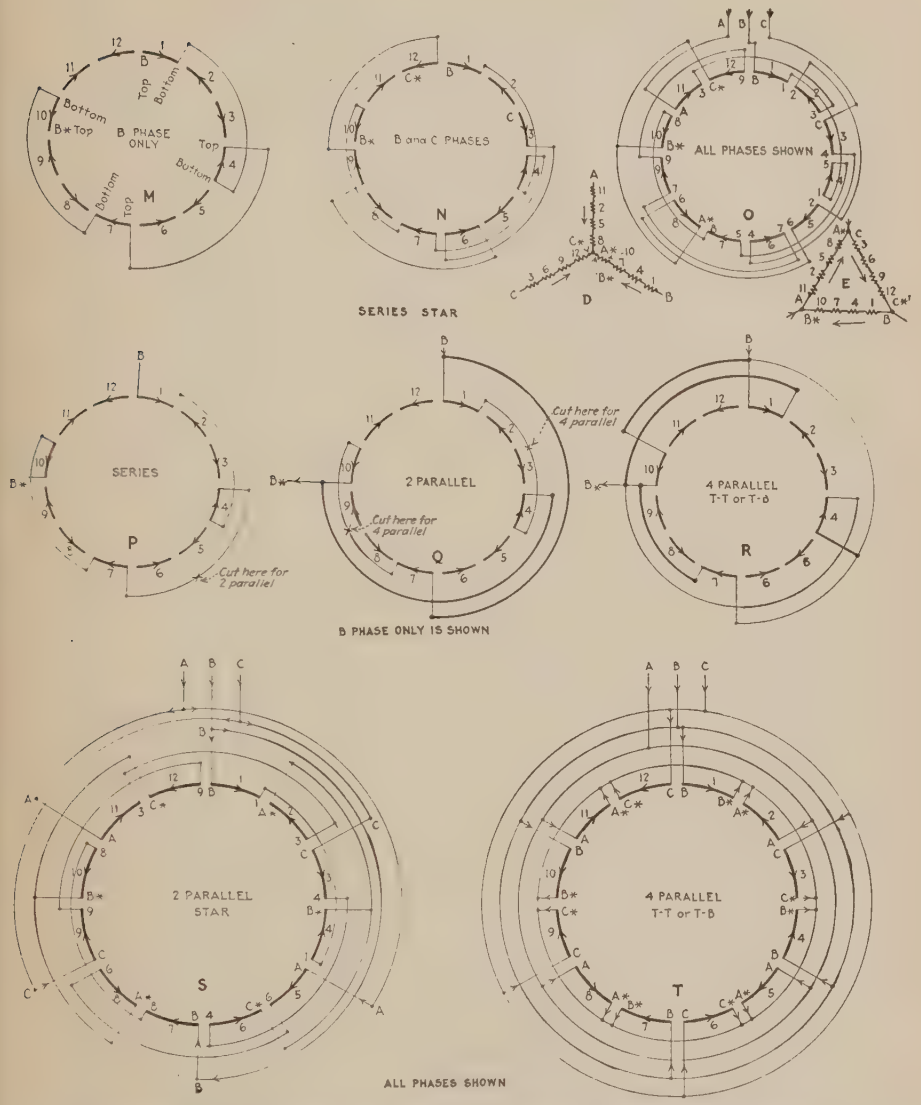


DIAGRAM H.—How single-line diagrams are drawn, both series and parallel.

Drawings *M*, *N* and *O* show three steps in making a single-line diagram, while drawings *P*, *Q*, *R*, *S* and *T* show how the series winding is changed to 2-parallel and 4-parallel. The drawings are all for a 4-pole, 3-phase, star winding with top-to-top connections. Only the *B* phase is shown in *M* and *N* while all three phases are drawn in *O*. In the drawings *P*, *Q*, and *R* the heavy lines show where changes have been made from the preceding drawing in order to get the 2-parallel or 4-parallel connection. Drawings *P*, *Q* and *R* show only the *B* phase but all three phases are shown in *S* and *T*.

pointing inward and those on the groups alternating first one arrow in one direction, then another in the opposite direction. This check is based on the fact that if direct-current flows inward from each line of a properly connected, 3-phase series winding, and a compass is held against each group, the polarity of each successive group will reverse.

Therefore, in constructing the single-line diagram, first the arrows are put on the groups, making one arrow point first in one direction and the next arrow in the opposite direction, and repeating this around the winding as in Diagram H. Then, put the group numbers on the curved lines as explained for 2-phase windings in Chapter IV. In any 3-phase winding, every third group (1 and 4) belongs to the same phase. The alternate groups of the same phase are in poles of opposite polarity. In other words, if group No. 1 is in a north pole, then group No. 4 will be in a south pole. Similarly, group No. 7 will be in a north pole of the same phase.

Top-to-top and Top-to-bottom Connections.—For a top-to-top (*T-T*) connection adjacent groups of the same phase are connected together. For a top-to-bottom (*T-B*) connection all groups in the north poles are first connected in series and then a short jumper is used to connect this series with the series of all south poles. The difference between the top-to-top (short) jumper and the top-to-bottom (long) jumper is explained in the chapter on 2-phase windings.

The Diagram H is for a top-to-top connection; consequently the first group is connected to the fourth. Calling the top lead of group No. 1 the *B* line, then connect groups No. 1 and No. 4 together, so that the arrows are followed. In other words, the bottom of group No. 1 connects to the bottom of group No. 4. Groups No. 4 and No. 7 are next connected together. The top of group No. 4 is connected to the top of group No. 7. Then, the bottom of group No. 7 is connected to the bottom of group No. 10, and as all the groups in the *B* phase have been covered, the top of group No. 10 is the star (*) connection. In passing through this series of groups from one end to the other, it will be noted that the passage is first clockwise (in group 1), then counter-clockwise (in group 4), then clockwise (in group 7) and then counter-clock-wise (in group 10). In other words, the direction alternates from one group to the next. This holds always with the top-to-top connection, but with the top-to-bottom connection the first series of groups is passed in one direction and the second series in the opposite direction.

Location of Line Leads.—In Diagram H after the *B* phase is connected as in *M*, the *C* phase is drawn in, as shown in *N*. To locate the start of the *C* phase, count over from group 1 to 3. Then the *C* line will connect to the top lead of group 3. The bottom of group 3 will connect to the bottom of group 6. Then the top of group 6 connects to the top of group 9, the bottom of 9 connects to the bottom of 12, and the top of group 12

forms the second star connection. After this phase is drawn, check it as outlined for the *B* phase.

The line lead for the *A* phase can be located at the top of either group 11 or group 5. In *O* of Diagram H the top of group 11 is used. The bottoms of groups 11 and 2 are connected together, the tops of groups 2 and 5 and the bottoms of groups 5 and 8. The top of group 8 forms the last star connection. The tops of groups 8, 10 and 12 may be connected together to form the star point. The jumper numbers are put on at the end of the groups as already explained in reference to Diagram *A* for 2-phase windings, page 21.

Line Leads May Be Brought Out at a Number of Points.—The small drawing *D* in Diagram H represents the star connection, showing the

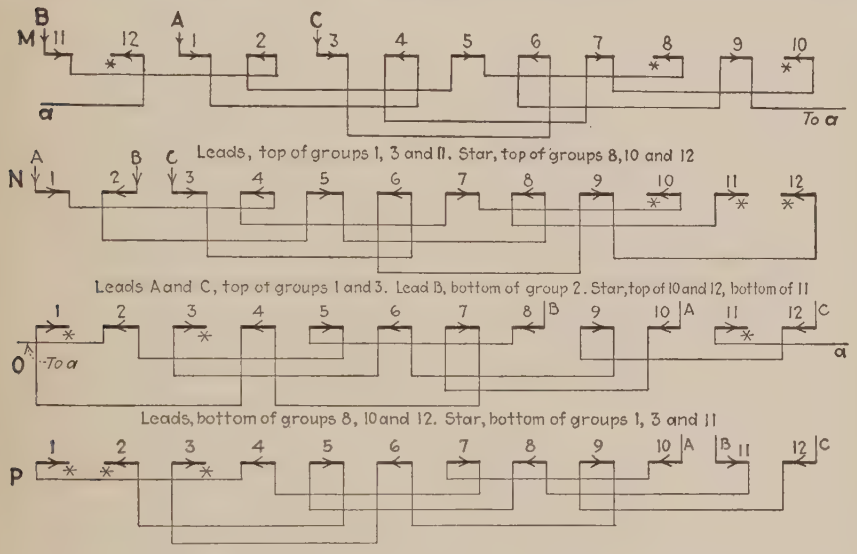


DIAGRAM I.—Various positions in which line leads may be placed.

These diagrams are all for a 4-pole, 3-phase, series winding with top-to-top connection (short jumpers). As will be seen, the line leads are put on in four different ways, but each is correct.

group numbers and the order in which they are passed through. At *E* is shown the way the series-star can be changed to a series-delta connection. The star connection is opened at the end of the *A* phase and connected to the beginning of the *C* phase. Likewise the end of the *C* phase is connected to the beginning of the *B* phase, and the end of the *B* phase to the beginning of the *A* phase. If we enter the delta winding on a line lead all three phases are passed through in the direction of the arrows until the starting point is reached.

In the explanation which has just proceeded, directions were given on where to place the line leads. It is not necessary, however, to place

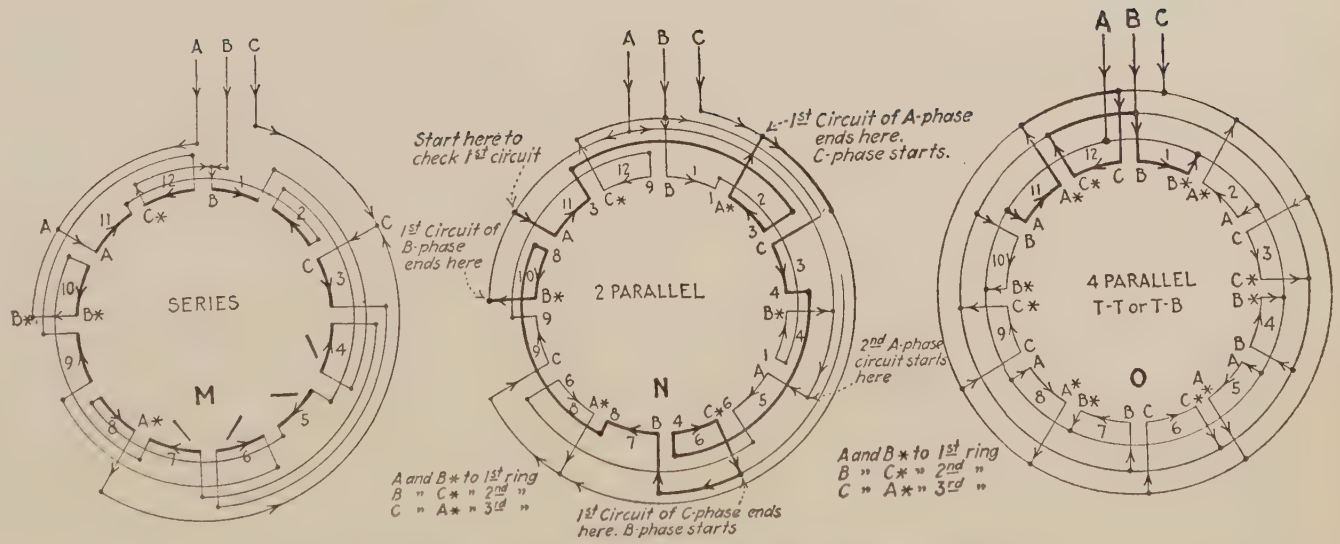

A B C
SERIES
M
Start here to check 1st circuit
1st Circuit of B-phase ends here
2 PARALLEL
N
1st Circuit of A-phase ends here. C-phase starts.
2nd A-phase circuit starts here
A and B* to 1st ring
B " C* " 2nd "
C " A* " 3rd "
1st Circuit of C-phase ends here. B-phase starts
4 PARALLEL
T-T or T-B
O
A and B* to 1st ring
B " C* " 2nd "
C " A* " 3rd "

DIAGRAM J.—Delta-connected windings, series, 2- and 4-parallel connections.

These drawings show a 4-pole, 3-phase winding connected top-to-top. The heavy oblique lines inside the circle at *M* shows how chalk marks may be put in an actual stator to indicate the direction of flow of current. The heavy lines in *N* show how to check a 2-parallel, delta winding. One of the two-parallel circuits has been checked by following the black lines. At O is the 4-parallel diagram. The heavy lines show the path in checking one of the four parallel circuits.

the leads always in one position. Diagram I shows four different methods of bringing out the line leads. The method shown at *M* is the most common and is used throughout this book, while that at *O* is used quite frequently. When selecting groups on which to attach line leads keep in mind that the arrows on alternating groups reverse, and assume that the current is flowing in on each line lead.

To check a series-delta connection start at any line lead. This will have attached to it two group connections. For illustration, suppose the *A* lead in *M* of Diagram J is taken. This drawing shows a series-delta, top-to-top diagram. As a starting point take one of the connections leading to the *A* lead and so mark it. For instance, in this diagram, take the *A* lead which is connected to group 11. Assume that the current is flowing in on this lead and check the direction of the current through the phase, remembering that every third group (1 and 4) should be passed through and that alternate groups are passed through in opposite directions. At the end of this phase, which is group 8, a connection is made to another line lead, *C*, which also has another group connection 3, attached to it. Using this lead as the next starting point, check the second phase in the same manner as the first. At the end of the second phase, at group 12, another line connection, *B*, is found. This has another group, group 1, connected to it. Use this connection to group 1 as the start of the third phase. This phase should end on the same line lead on which the first phase started, at group 11. This is the marked lead.

When checking a wound stator, a piece of chalk should be used to mark each group as it is passed through. Instead of making an arrow on the end of the coils composing a group, it is much easier to draw an inclined straight line, as shown in *M* of Diagram J. The inclination of the line toward the center of the machine indicates the direction of flow of current through the group. These lines have been drawn at groups 4-5-6-7, to illustrate their use.

How Parallel Connections Are Obtained from Series Connections.—Changing series to 2-parallel and 4-parallel connections is shown at *P*, *Q* and *R* of Diagram H. All the drawings in this figure are for star connections with top-to-top jumpers. Drawings *P*, *Q* and *R* show the *B* phase only. *P* is the drawing giving the series connection of the *B* phase. Drawing *Q* shows the 2-parallel connection which is obtained from the series connections. The changed connections in drawing *Q* are shown by the heavy lines. The series of four coils in *P* is cut open at the middle point, the top of group 7 is connected to the *B* line and the bottom of group 10 is connected to the star point.

At *S* is shown the entire 2-parallel star connection with all three phases drawn in. Note that the two star connections are not joined together. The electrical performance is not affected by failure to join

the two stars and on large machines where the wire is of considerable size, two splices and some cable are saved by omitting the connection between the two stars when a change is made from series to 2-parallel.

A 4-parallel connection is shown at *R*. Each connection consists of only one group in this case. This is because there are only twelve groups while there are 4 parallel circuits for each of the 3 phases. At *T* is shown the complete 4-parallel star winding with all 3 phases drawn in.

The method of drawing and checking parallel-delta connections is shown in Diagram J at *N* and *O*. These windings are for top-to-top connections. A 2-parallel delta connection will have four taps to each

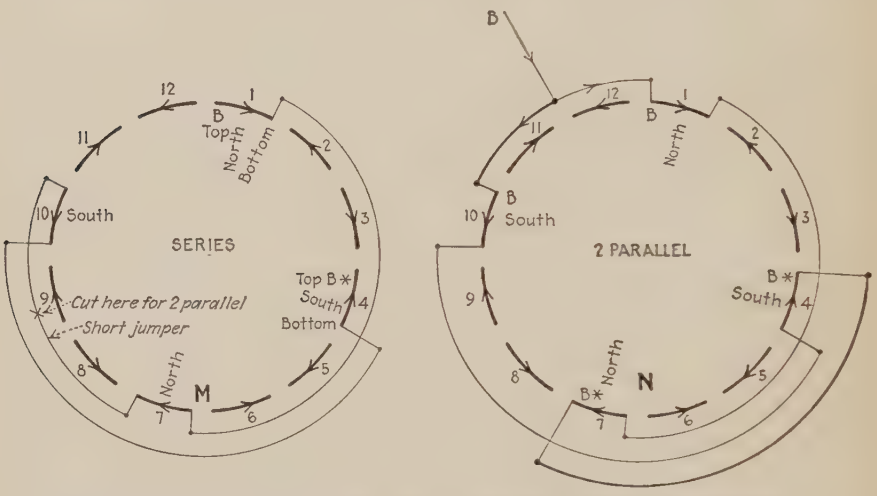


DIAGRAM K.—Top-to-bottom type of connection, series and 2-parallel.

This shows a 4-pole, 3-phase, star winding with the top-to-bottom, or long, jumper. At *M* is a series connection, while at *N* is a 2-parallel connection. The heavy lines in *N* show where changes have been necessary to convert the series to the 2-parallel connection.

line lead. Then to check the winding take any one line lead as *A* in drawing *N* of Diagram J. Take any one of the four taps from this line lead, such as the tap connected to group 11. Assume that the current is flowing inward on this tap. Then trace through the groups of this phase, remembering that every third group (1 and 4) is in this phase and that alternate groups should be passed through in opposite directions. Mark all the leads and also the groups as well as the direction in which they are passed through. After the groups in this phase, groups 11 and 2 are passed through, the *C* phase begins. Select a tap on this *C* phase, as that going to group 3. Check through groups 3 and 6 to the *B* line lead. Check this phase through groups 7 and 10. After passing through these three half-phases, we come to the line lead started on, which is *A* in group 11. We shall have marked six taps which were

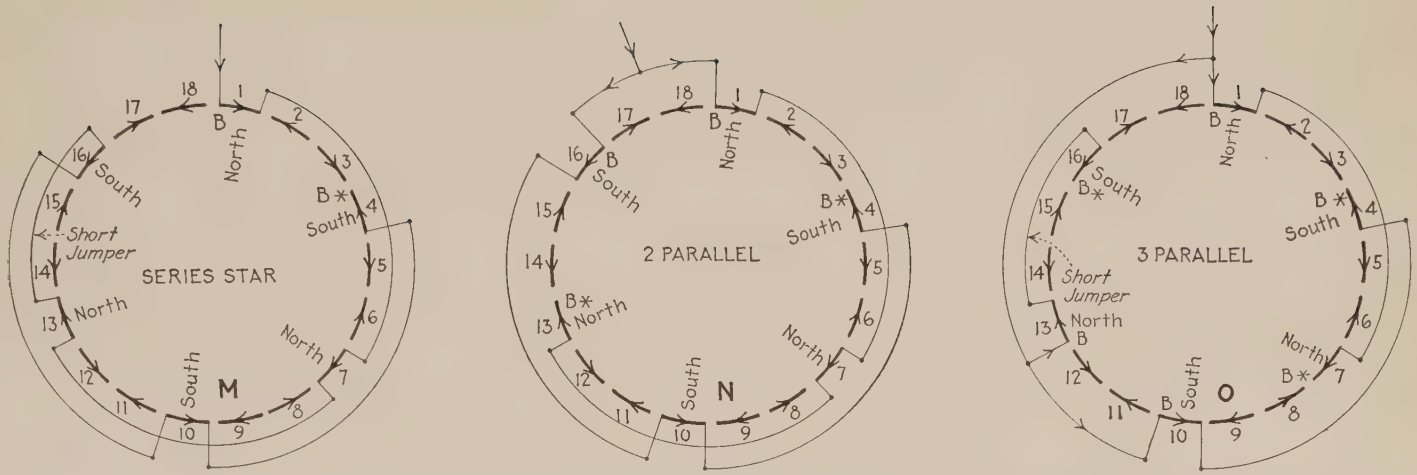


DIAGRAM L.—A 6-pole winding connected series and parallel. This is a 3-phase star winding with top-to-bottom (long) jumpers.

passed. Then starting again on the first line lead, select another tap, this time on group 5, in the *A* phase. Check this circuit through. Then follow each remaining tap at the end of each remaining half-phase until the starting point is reached.

At *O* is a 4-parallel, delta connection. Each group is the beginning and the ending of a phase. To check such a winding pass first through any *A* group, then a *C* group, then next a *B* group. This completes the first circuit. Then select another tap leading from a line and pass again through the *A*, *C* and *B* groups. When this is done four times all of the windings will have been included.

The method of constructing a top-to-bottom diagram is shown in Diagram K. In this type of diagram all groups in one phase under poles of the same polarity are connected in series. Then a reversing jumper connects this series with the groups under poles of the opposite polarity and these also are all connected in series. When a 3-phase motor has top-to-bottom jumpers, groups 1 and 7 are connected together. In *M* of Diagram K the top of group 1 is used for a line lead and the bottom connected to the top of group 7. This forms the first series of coils in this phase, as half of the groups in this phase have been covered. Then a short jumper connects the bottom of group 7 to the bottom of group 10. The top of group 10 is then connected to the bottom of group 4, and the top of group 4 forms the star connection. At *N* of Diagram K is shown the 2-parallel, top-to-bottom connection. Note that the short jumper has been cut open, one end going to a line lead and the other to the star connection.

Other examples of the top-to-bottom connection are included in Diagram L. This shows a 6-pole, series-star diagram, connected top-to-bottom. At *M* is the series connection. At *N* is the 2-parallel connection in which the three north-pole groups are in one circuit and the three south-pole groups in the other circuit. In *O* a 3-parallel (three-circuit) top-to-bottom connection is shown. In this diagram one of the circuits has a top-to-top connection, where groups 13 and 16 are connected together. The reason is that these two were originally connected together by the short jumper.

CHAPTER VI

DIRECTIONS FOR USING TABLES FOR CONNECTING ENDS OF GROUPS

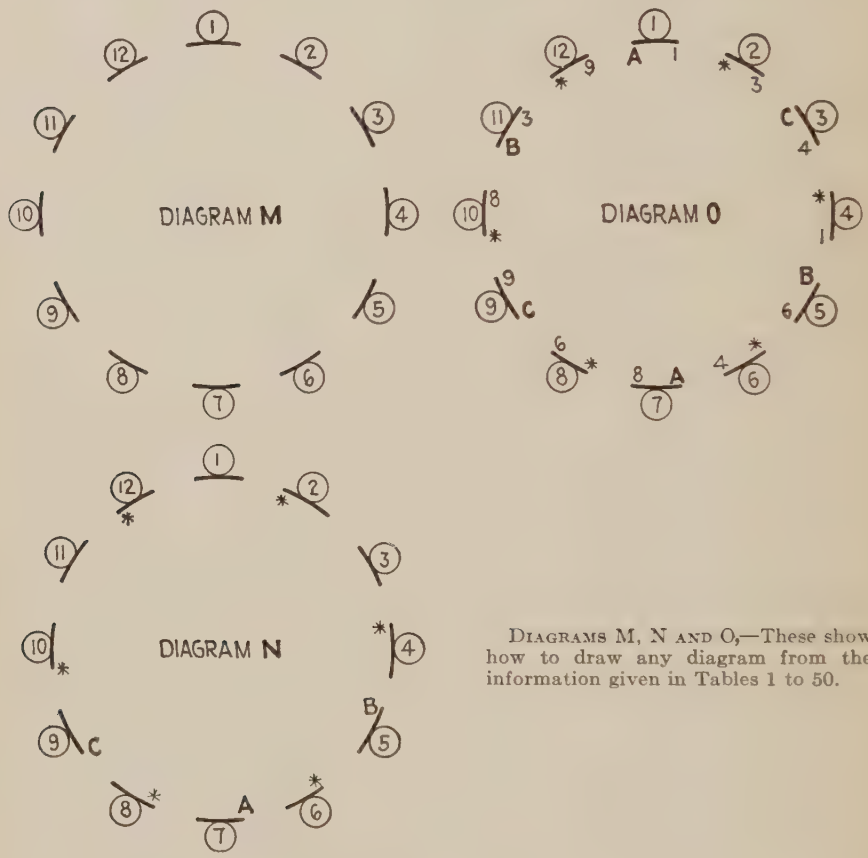
Tables 1 to 50 have been compiled with the series winding as the base; that is, all tables for top-to-top (*T-T*) and top-to-bottom (*T-B*) connections show the full lettering for the series connection only. Then for any parallel connection the lettering is changed only at the point on each group of the parallel connection line where a change is made from the standard series group lettering with ditto-marks used to indicate when the series line lettering and numbering is to be used. This method makes the difference between any two of the many connections shown in the tables stand out so as to be read at a glance.

These tables, 1 to 50, and particularly those for the 16- to 24-pole windings, can be used to lay out and construct a connecting diagram for any desired connection within the range of the poles and phases shown in the tables.

How Changes for Parallel Windings Are Shown in the Tables.—When these connecting tables are used to lay out new winding diagrams, the ditto marks in the blank spaces of the parallel connection lines must be taken into consideration. The way to do this is to pick out the connection line for which a new diagram is needed and fill in the group numbers and letters as given in the table from the series connection line, where the ditto marks indicate that the connections for ends of groups are the same. The tables as they stand where ditto marks appear, show at a glance what changes are required for any connections, since only the changes in ends of groups for parallel connections are shown with the ditto marks indicating the connections that are the same for the ends of the different groups. This will be particularly useful when making reconnections for voltage changes.

How to Make up New Diagrams from Information in Tables.—The procedure when using the tables to make up new diagrams is as follows: Lay out a circle having as many short lines or arcs as there are pole phase groups (see Diagram M). The number of these groups is given in each table in the top line headed "group numbers." Each of these arcs should be at least $\frac{1}{4}$ to $\frac{3}{8}$-inch long for clearness. After drawing the arcs, number the groups in a clockwise direction to correspond to the table. (See Diagram N).

To illustrate the use of the tables in constructing diagrams, a 4-pole, 2-parallel, star *T*-*T* connection layout will be made from Table 5. The first step is to lay off twelve arcs (Diagram M) to represent the number of pole-phase-groups, given in the top line of Table 5. The next step is to number these groups as shown in Diagram N. The next step is to look along the desired connection line in the tables, until the first figure or letter (not ditto marks) is encountered. Then look up to the



DIAGRAMS M, N AND O,—These show how to draw any diagram from the information given in Tables 1 to 50.

top of the table and locate the group number and whether the mark is at the top or bottom of the group.

In the example under construction, we look along the second line in Table 5, until we see the (*) mark which we find is at the top or left-hand side of group 2. We then put a (*) star at the top or left-hand side of group 2 in the skeleton diagram. We next proceed along the 2-parallel line and locate all other figures, letters or marks (not dittoed) given in the table and transmit these marks to the proper group and proper end

of each group in the diagram layout. Diagram N shows this stage of the diagram. Note that the marking shown in Diagram N corresponds in every respect with that shown on the 2-parallel line of Table 5.

We next consult the series line of the table being used to construct the new diagram. Start with group 1 in both table and diagram and fill in the markings at the top and bottom of each group, using the first line marking of the table for the new diagram until a mark is encountered on the diagram that differs from the first line marking in the table for a series connection. We then skip this mark and proceed to mark the rest of the group ends to correspond with the first line of the table until the previous marks first put on the diagram are met, which do not follow the first line but agree with the second line markings.

Then, for the example under consideration, the marking for group 1, first line, is *A*-1 and as both ends of group 1 in the diagram are blank, we put *A* at the left and *1* at the right of group 1, as in Diagram O. The first line of Table 5 shows group 2 marked 2-3. The top of group 2 in the new diagram had been previously marked with a (*). In this case we simply put the 3 at the right end or bottom of group 2 which now reads *-3 (See Diagram O). Group 3 in Table 5 is marked C-4 and this is repeated (following the ditto marks) in the new diagram. Group 4 reads 5-1, but the new diagram (See Diagram O) has a * at top. This group then becomes *-1. The marking is continued in this manner until all groups are marked.

Diagram O shows the groups all marked and the new diagram ready to have the group ends connected together with jumpers. These jumpers connect like numbers together; that is, one to one, three to three, etc. Figure 30 shows the finished diagram, with the leads and star connection made.

When it is desired to construct a diagram for parallel connection, first mark the skeleton group diagram with the markings given on the desired connection line in the table. Then fill in with the series marking in the same way as already explained.

CHAPTER VII

SPECIAL DIAGRAMS FOR TWO AND FOUR-SPEED MOTORS

This chapter contains a number of special diagrams used mostly for 4- and 6-pole windings, but the principle can be applied to windings with a larger number of poles by studying the diagrams presented. Figure 1 shows a 2-phase, 4-pole winding having only twelve coils. In this connection one coil forms a group and there are twelve groups, connected to form eight groups or four per phase, giving two groups of two coils and two groups of one coil per group or six coils per phase.

Figures 2 and 3 are diagrams arranged for 120-deg. lead spacing for rotor windings connected series-star, 4, and 6 poles.

How Two-parallel Windings Can Be Made by Changing Leads Outside the Motor.—Figures 4, 5, 6, 7, 8 and 9 are diagrams arranged so that a series of 2-parallel windings can be had by changing the leads outside the motor. Thus the windings can be arranged for two voltages, 110 and 220, or 220 and 440. This is quite an advantage for plants that are changing over from one voltage to another, as the spare motors can be connected according to these diagrams and arranged for either voltage in 10 to 15 minutes. It is also of advantage to contractors who have portable tools and meet with different voltages on each job. While the diagrams cover the 4- and 6-pole motors, a study of the method used will enable the average winder to construct a diagram for any winding.

Star-delta Method of Starting Motors.—Figures 10, 11, 12 and 13 are diagrams arranged for the star-delta method of starting motors. The connections are for 4-pole, series, 2- and 4-parallel and 6-pole series windings. The lead arrangement is given in Fig. 10 and applies to the four diagrams.

Four-speed, Double-winding Motors.—Figures 14, 15, 16 and 17 are connecting diagrams that apply to 4-speed, double-winding motors. Figure 17 gives the controller connections. In this type of motor the winding is designed for a constant horsepower at all speeds, using two windings, one for 4 and 8 poles, 1800 and 900 r.p.m. and the second winding for 6 and 12 poles, 1200 and 600 r.p.m.

When winding the stator put the 4-pole winding on first, in the bottom of the slots, and the 6-pole winding on top and connect each winding on opposite sides. That is, the 4-pole on the right hand side and the 6-pole on the left hand, or vice versa.

When connecting up a 4-speed, 2-winding stator, if one side or winding is picked up in a clockwise direction when facing the stator, the opposite side should be connected by picking up the groups in a counterclockwise direction. Failure to observe this rule will mean that on first speed the motor will run in one direction and on second speed in the opposite direction. The third speed will be the same as the first and the fourth the same in direction as the second.

To obtain 4 and 8 poles or 6 and 12 poles from one winding, we will have to resort to a salient and consequent pole connection. Also to get a constant horsepower, a series-delta connection will be used for the high speed, 1800 and 1200 r.p.m., 4 and 6 salient pole windings, and a 2-parallel, star connection for each low speed 900 and 600 r.p.m., 8 and 12-pole winding. The way this connection keeps the hp. constant is explained below. A two-layer (diamond mush coil) lap winding is generally used for each winding.

On all multi-speed induction motors the coil pitch is made one hundred per cent for the lowest speed of each winding. Then for a 4- and 8-pole, 48-coil winding the coil pitch is 48 ÷ 8 equals 6, or 1 and 7, and for the 6- and 12-pole, 48 ÷ 12 equals 4, or 1 and 5, which is 50 per cent pitch for the 4- and 6-pole windings.

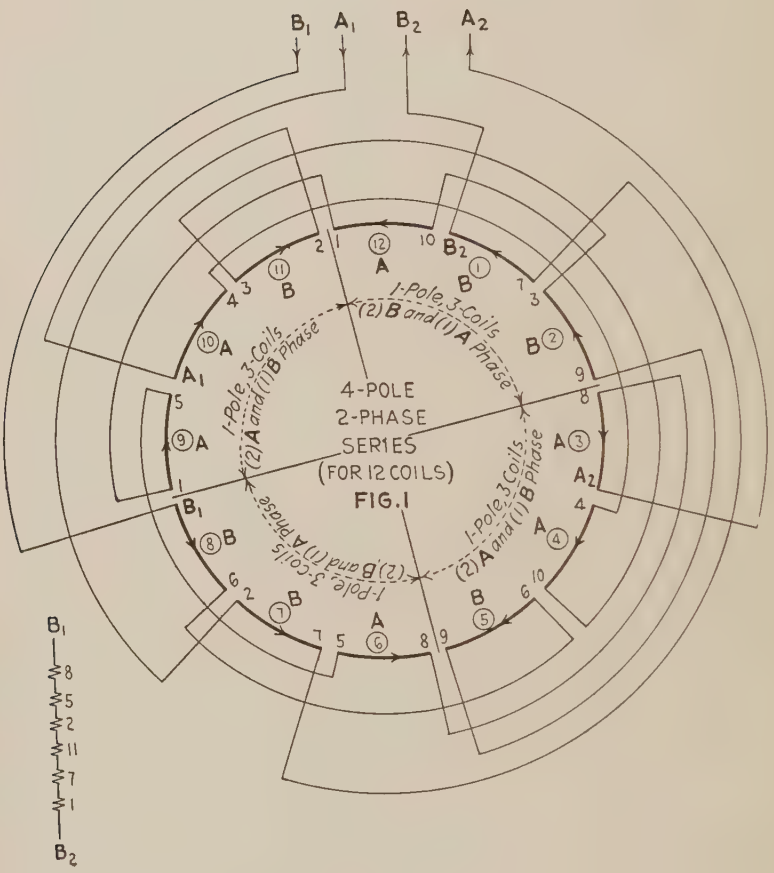
Figure 14 is a series-delta connection. Note that the delta is opened at one point. This is to prevent circulating currents, as only one winding is in use at one time. If the winding not in use should form a closed circuit it would act as the secondary of a transformer. To overcome this both windings are opened as indicated.

Figure 15 shows how the 8 poles are obtained. Note that the direction of the current as indicated by the arrows is reversed in groups 2, 4, 6, 8, 10 and 12, and all arrows point the same, thus forming poles between each group. Figure 15 is a 2-parallel star connection.

How the Horsepower Is Kept Constant.—The way these two connections tend to keep the horsepower constant is as follows: The series-delta connection is good for 220 volts, 15 amp., 1800 r.p.m. 5 hp. The wire in each phase will carry 8.61 amp.

Changing to parallel-star, the voltage per phase is 110 volts, or the line voltage should be 110 × 1.73 equals 190 volts. Then if 220 volts are applied, it will be 16 per cent over voltage, and as each leg of the star circuit is good for 8.61 amp., the line current could be 2 × 8.61 equals 17.22 amp., which is an increase of 14.8 per cent. Then the net result is to reduce the total turns and increase the current-carrying capacity, both of which will increase the maximum torque and tend to keep the horsepower constant. A multi-speed induction motor of constant horsepower will be about 150 per cent larger than a corresponding single-speed motor of the same horsepower at the highest speed.

Figure 16 shows the 6- and 12-pole connection which is 2-parallel star for 12 poles and series delta for 6 poles. Figure 17 shows the controller connection for the four speeds.


B1
A1
B2
A2
4-POLE
2-PHASE
SERIES
(FOR 12 COILS)
FIG. 1
1-Pole 3-Coils (2)B and (1)A Phase
1-Pole 3-Coils (2)A and (1)B Phase
1-Pole 3-Coils (2)B and (1)A Phase
1-Pole 3-Coils (2)A and (1)B Phase
B1
8
5
2
11
7
1
B2

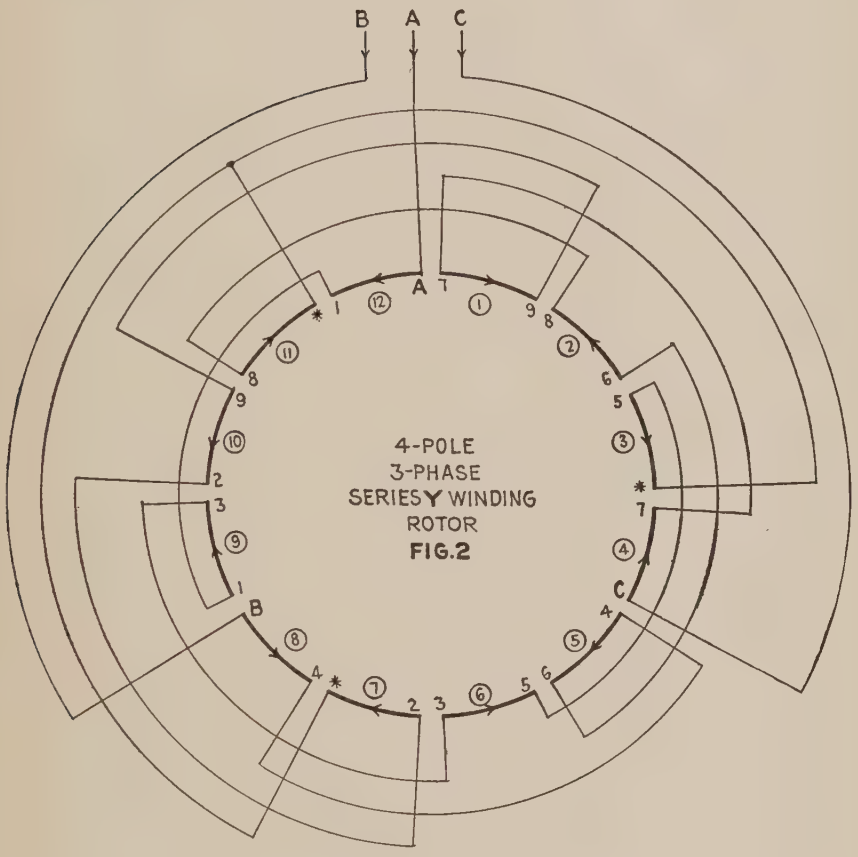
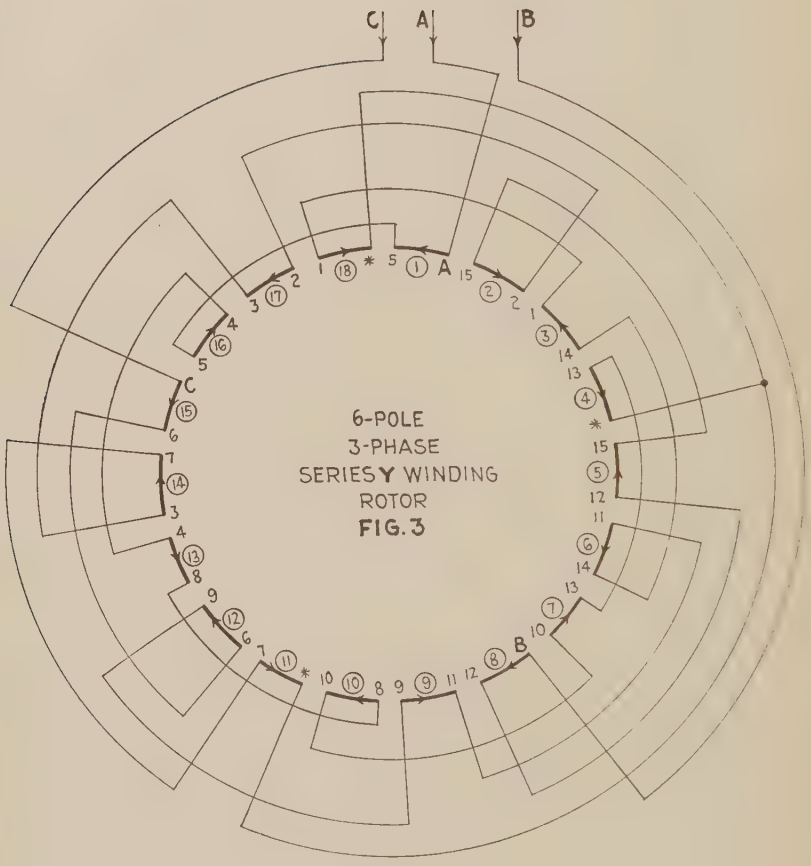


FIG.2


C
A
B
6-POLE
3-PHASE
SERIES Y WINDING
ROTOR
FIG. 3

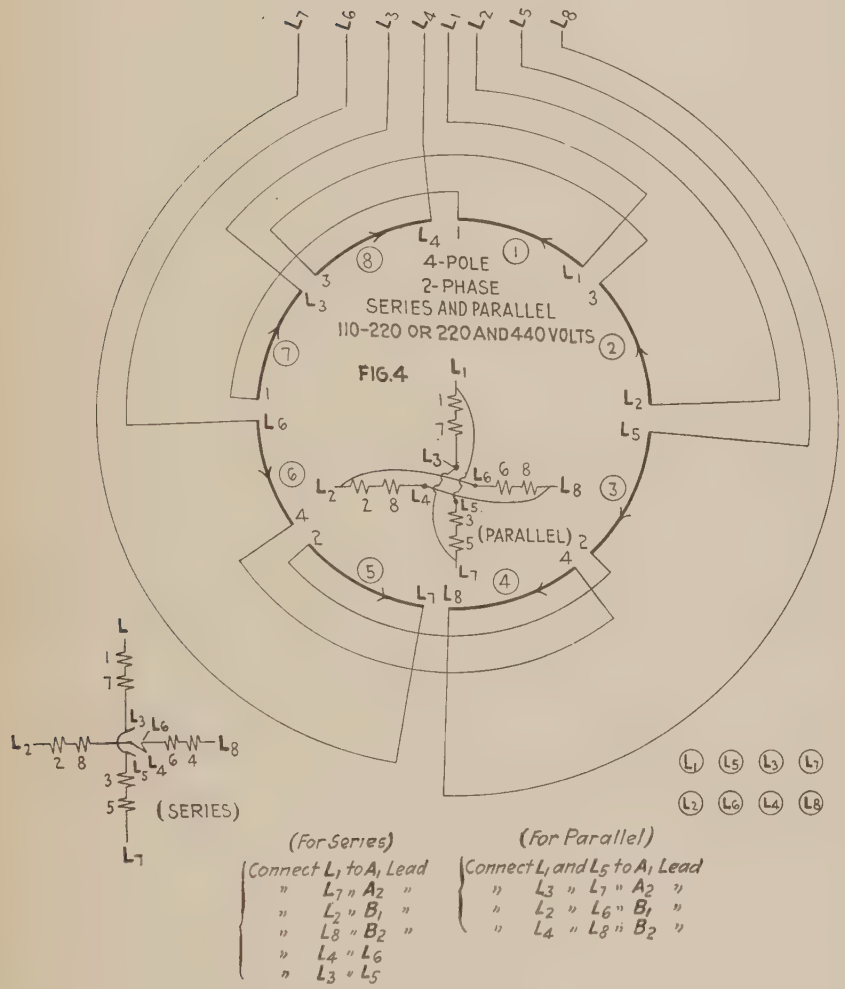


FIG. 4

(For Series)

Connect L_1 to A_1 Lead
" L_7 " A_2 "
" L_2 " B_1 "
" L_8 " B_2 "
" L_4 " L_6
" L_3 " L_5

(For Parallel)

Connect L_1 and L_5 to A_1 Lead
" L_3 " L_7 " A_2 "
" L_2 " L_6 " B_1 "
" L_4 " L_8 " B_2 "

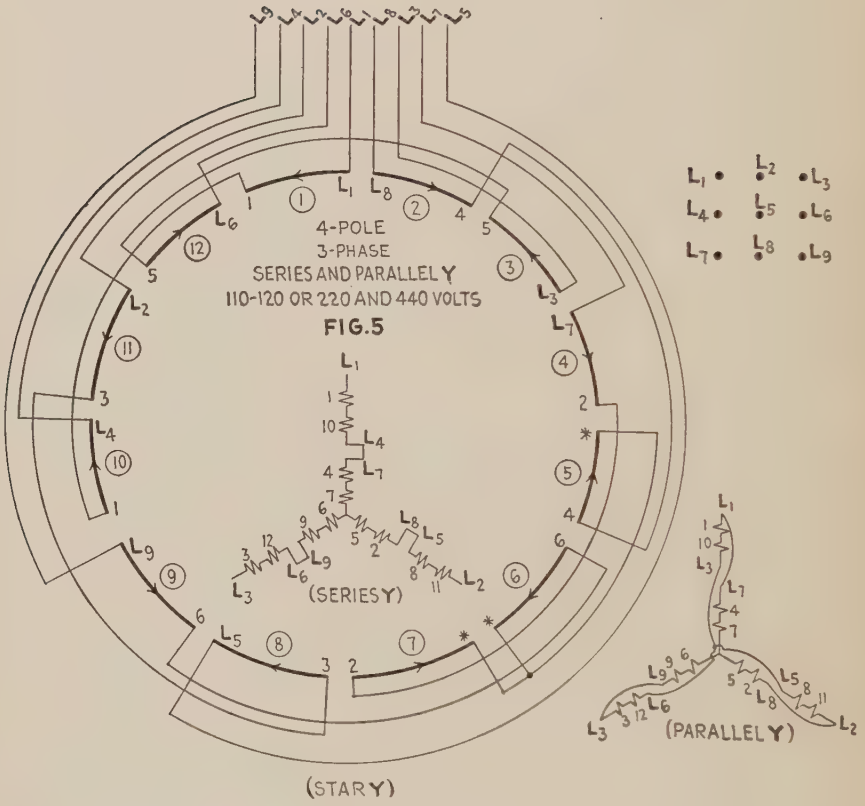


FIG. 5

For Series Star L_1 - L_2 - L_3 are leads
Connect L_4 and L_7 together, also L_5 to L_8, and L_6 and L_9

For Parallel Star Connect L_1 and L_7 to A Lead
" " " " L_2 " L_8 " B "
" " " " L_3 " L_9 " C "
and connect L_4-L_5 and L_6 together

Connectors are arranged so motor can be changed without removing end bells

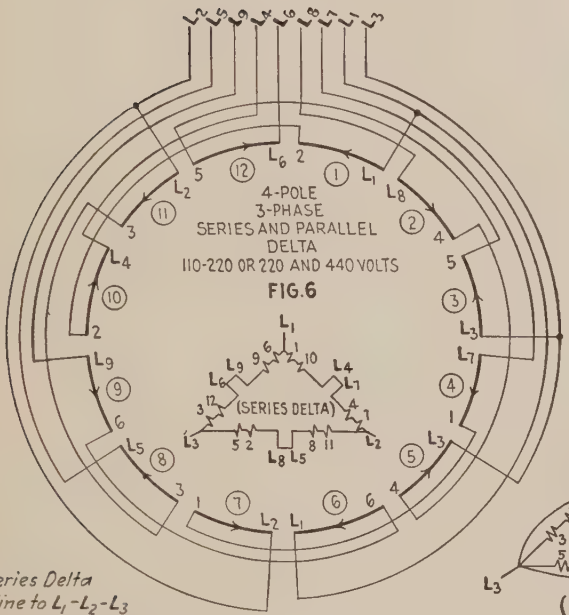
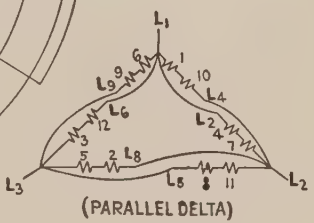
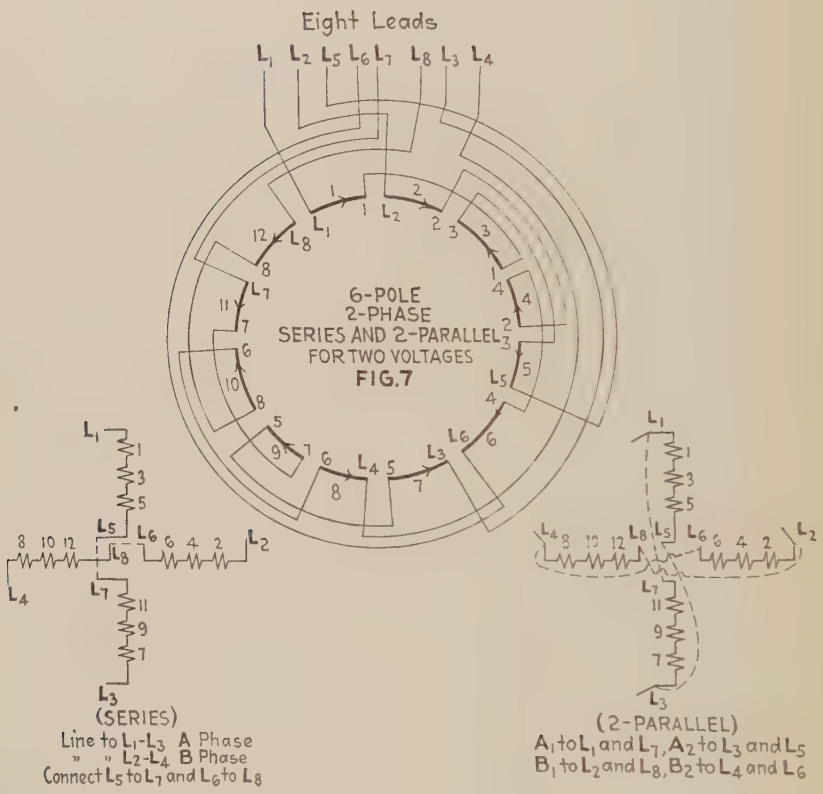


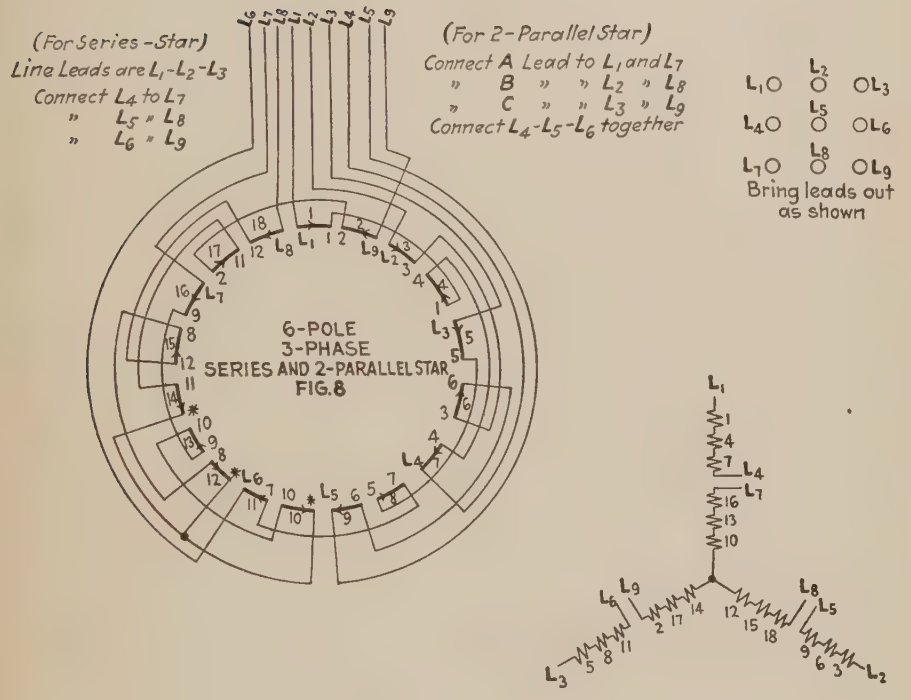
FIG.6

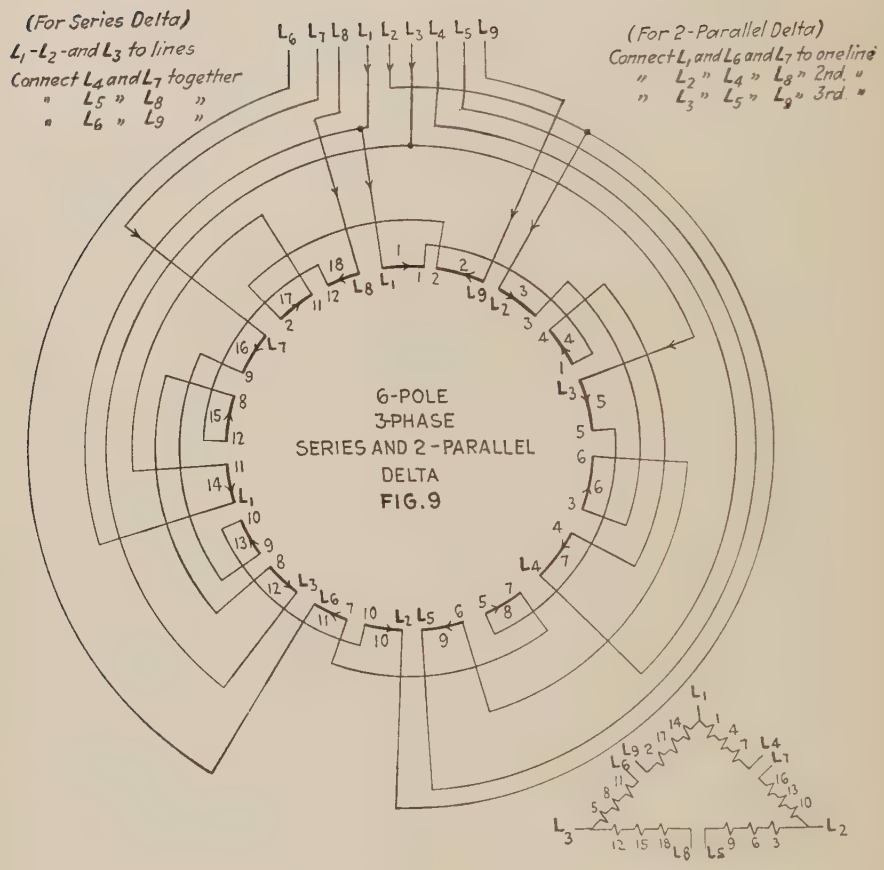


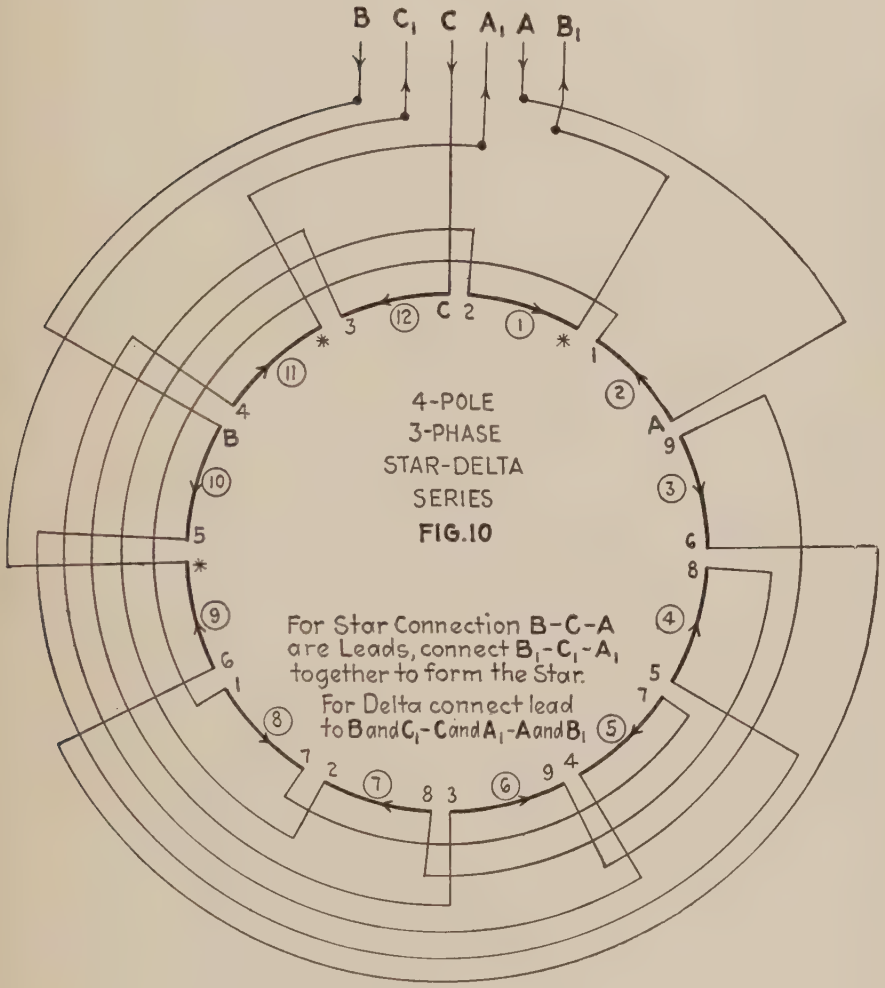
For Series Delta
Connect line to L_1-L_2-L_3
Connect together L_4 to L_7, and L_5 to L_8, and L_6 to L_9

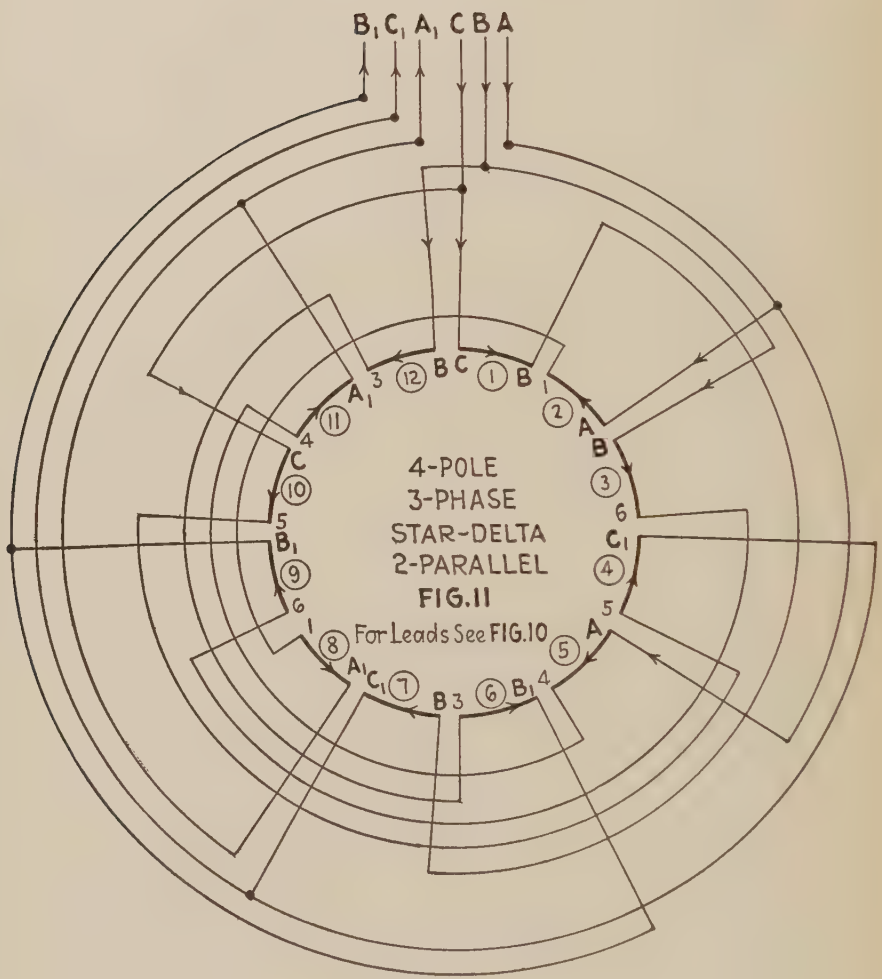
For Parallel Delta connect lines to L_1-L_2-L_3
Connect L_7 and L_6 to L_1 to A line
" L_4 " L_8 " L_2 " B "
" L_5 " L_9 " L_3 " C "

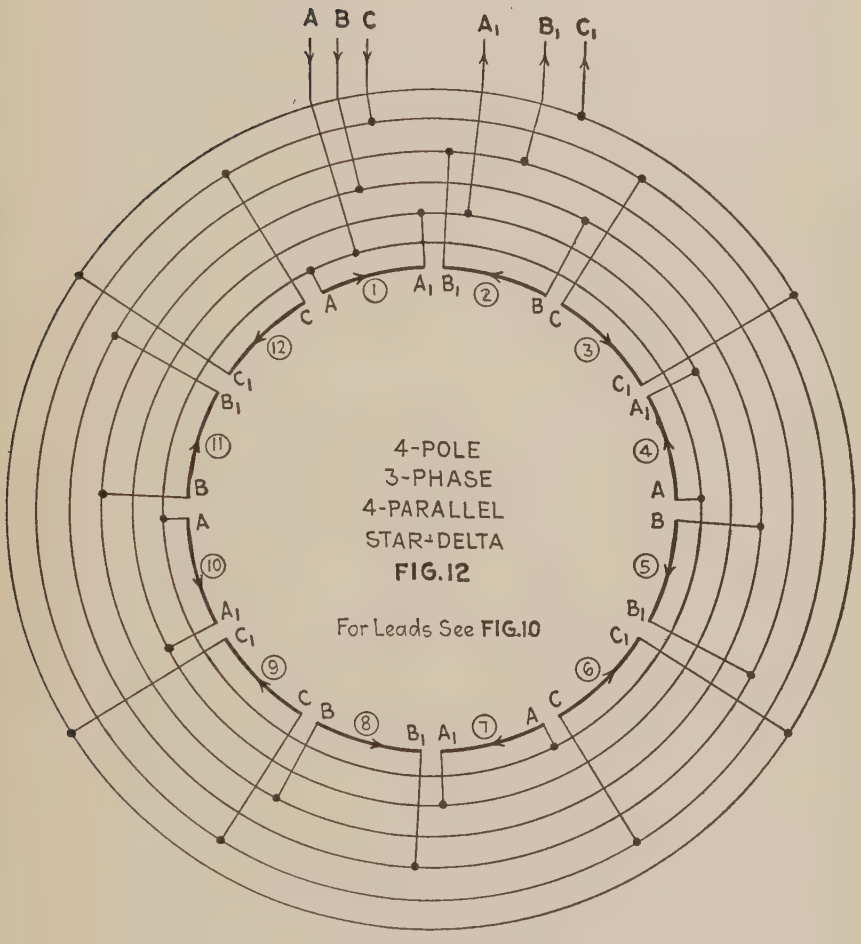

Eight Leads
L1 L2 L5 L6 L7 L8 L3 L4
6-POLE
2-PHASE
SERIES AND 2-PARALLEL
FOR TWO VOLTAGES
FIG.7
(SERIES)
Line to L1-L3 A Phase
" " L2-L4 B Phase
Connect L5 to L7 and L6 to L8
(2-PARALLEL)
A1 to L1 and L7, A2 to L3 and L5
B1 to L2 and L8, B2 to L4 and L6

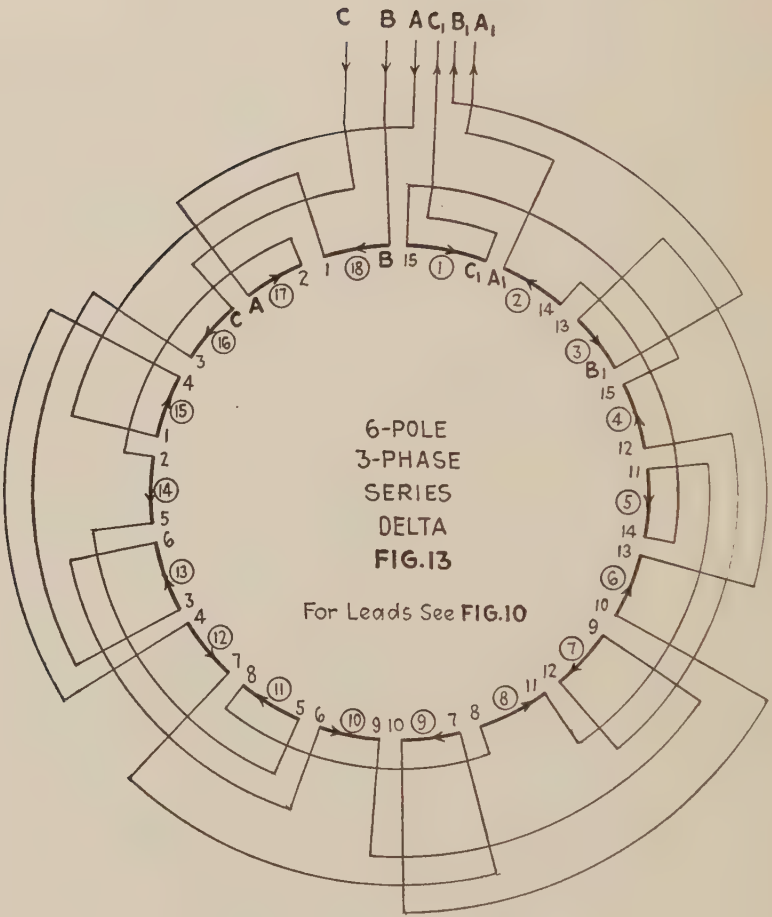

(For Series-Star)
Line Leads are L_1-L_2-L_3
Connect L_4 to L_7
" L_5 " L_8
" L_6 " L_9
(For 2-Parallel Star)
Connect A Lead to L_1 and L_7
" B " " L_2 " L_8
" C " " L_3 " L_9
Connect L_4-L_5-L_6 together
L_1 L_2 L_3
L_4 L_5 L_6
L_7 L_8 L_9
Bring leads out as shown
6-POLE
3-PHASE
SERIES AND 2-PARALLEL STAR
FIG. 8


(For Series Delta)
L1-L2-and L3 to lines
Connect L4 and L7 together
" L5 " L8 "
" L6 " L9 "
(For 2-Parallel Delta)
Connect L1 and L6 and L7 to one line
" L2 " L4 " L8 " 2nd. "
" L3 " L5 " L9 " 3rd. "
L6 L7 L8 L1 L2 L3 L4 L5 L9
6-POLE
3-PHASE
SERIES AND 2-PARALLEL
DELTA
FIG. 9
L1
L2
L3
L4
L5
L6
L7
L8
L9


B C1 C A1 A B1
4-POLE
3-PHASE
STAR-DELTA
SERIES
FIG.10
For Star Connection B-C-A are Leads, connect B1-C1-A1 together to form the Star.
For Delta connect lead to B and C1-C and A1-A and B1


B1 C1 A1 C B A
4-POLE
3-PHASE
STAR-DELTA
2-PARALLEL
FIG.11
For Leads See FIG.10


A B C
A1 B1 C1
4-POLE
3-PHASE
4-PARALLEL
STAR-DELTA
FIG.12
For Leads See FIG.10


C B A C1 B1 A1
6-POLE
3-PHASE
SERIES
DELTA
FIG.13
For Leads See FIG.10

1 2 3 4 5 6 7
4 Speed
6 & 12 Pole
FIG. 16
12 Pole
6 Pole
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
4 Speed
4 & 8 Poles
FIG. 15
1 2 3 4 5 6 7
FIG. 14

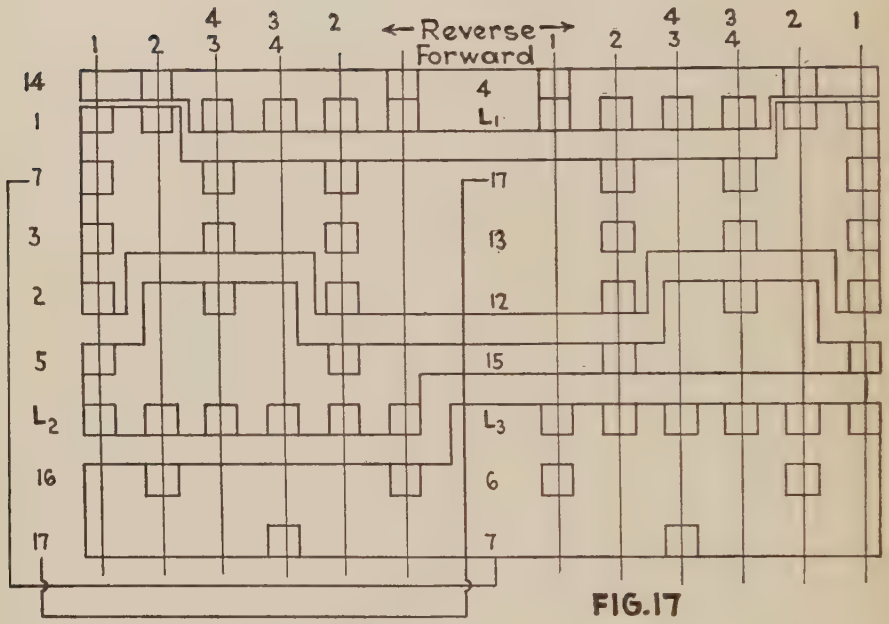


FIG.17

Reverse

1st. L_1-4, L_2-5, L_3-6 (L_3-5, L_2-6)
1-7-3-2 together = 2 Par. Y-600 R.P.M.

Rev.

2nd. L_1-14, L_2-15, L_3-16, (L_2-16, L_3-15)
1-7-13-12 together = 2 Par. Y 900 R.P.M.

Rev.

3rd. L_1-1, L_2-2, L_3-7 (L_2-7, L_3-2)
7-3 together = Ser Δ-1200 R.P.M.

Rev.

4th. L_1-1, L_2-12, L_3-17 (L_2-17, L_3-12)
13-17 together = Ser Δ-1800 R.P.M.

CONTROLLER DIAGRAM
FOR
4-SPEED MOTOR
13 LEADS
AS PER
FIGS. 14, 15 AND 16

CHAPTER VIII

TWO-POLE, TWO- AND THREE-PHASE, STAR AND DELTA DIAGRAMS AND CONNECTING TABLES

This chapter contains six diagrams for 2-phase, 3-phase star and 3-phase delta, all showing top-to-top windings. There are only two connections that are available and these are series and 2-parallel.

A study of Figs. 18 to 23 and Tables 1 and 2 will show that to change from a series to a 2-parallel connection or vice versa is a simple matter. Also changing from a series star to a series delta is equally simple.

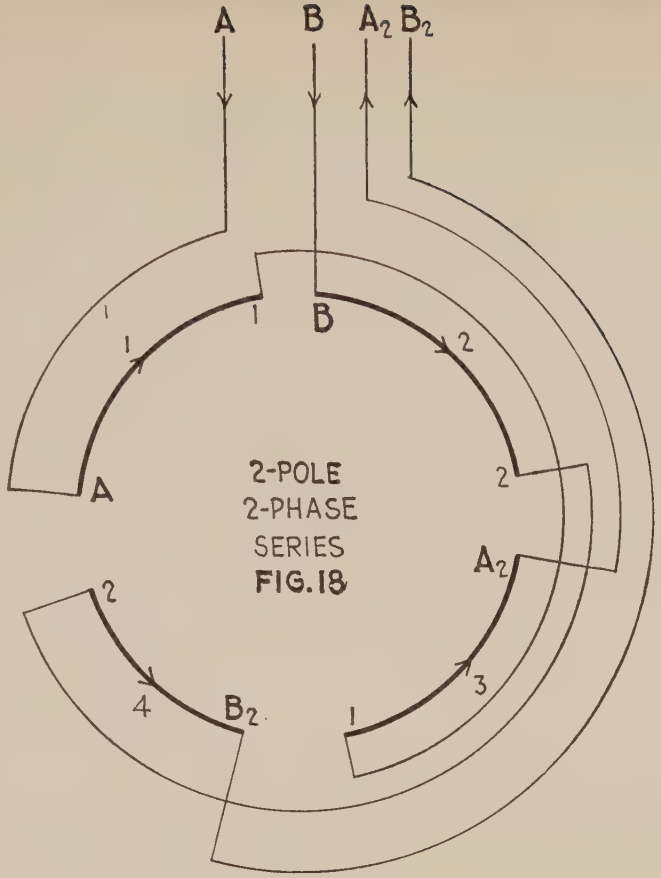
Examples of such changes are given in the chapters that follow, illustrating the different points in making changes in connections and using the accompanying tables and diagrams.

TABLE 1.—CONNECTIONS FOR ENDS OF GROUPS OF A 2-POLE, 2-PHASE WINDING

2-pole, 2-phase, top-to-top					
Pole number		I		II	
Group number		1	2	3	4
Connection	Fig. No.	T-B	T-B	T-B	T-B
Series	18	A 1	B 2	A_2 1	B_2 2
2-parallel	19	" A_2	" B_2	" A	" B

CHART A.—UNEQUAL COIL GROUPING OF A 2-POLE, 2-PHASE WINDING—SEE FIGS. 18 AND 19

2-pole, 2-phase, top-to-top				
Number of coils	Group number			
	1	2	3	4
18	4	5–1	5–1	4
54	13	14–1	14–1	13
62	15	16–1	16–1	15



2-POLE
2-PHASE
SERIES
FIG. 18

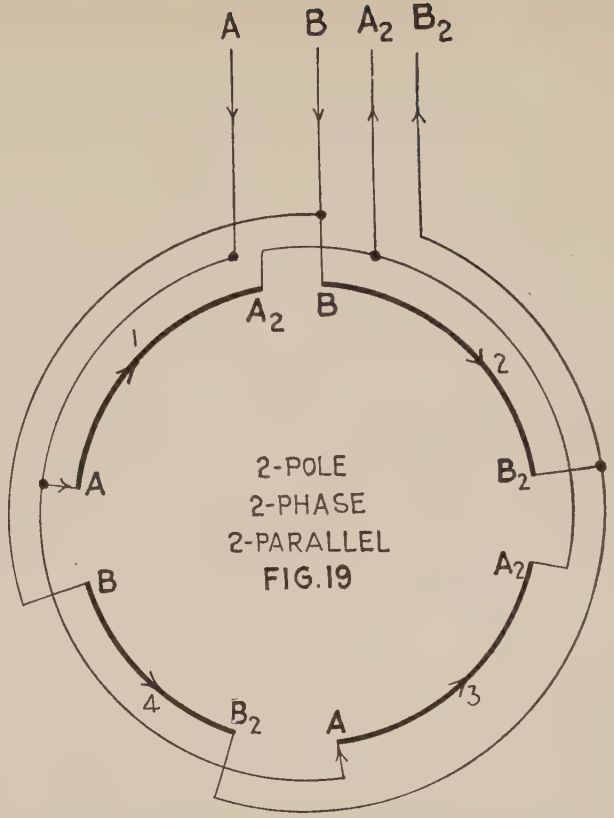
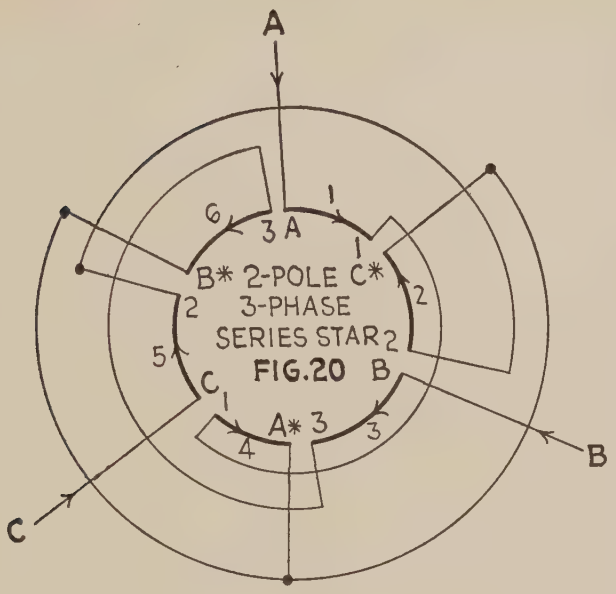


FIG. 19

CHART B.—UNEQUAL COIL GROUPING FOR A 2-POLE, 3-PHASE WINDING—SEE FIGS. 20, 21 AND 22, 23

2-pole, 3-phase, top-to-top						
No. of coils	Group numbers					
	1	2	3	4	5	6
62	10	10	11–1	10	11–1	10


A
B
C
6
1
3 A
1
B* 2-POLE C*
2
2
3-PHASE
5
SERIES STAR 2
C
FIG.20
B
1
A* 3
3
4

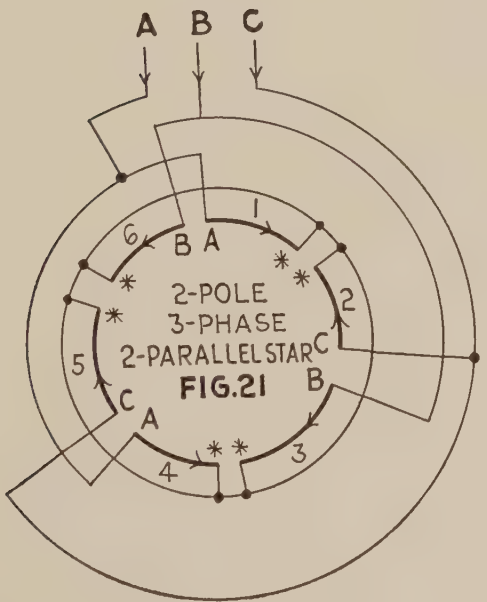
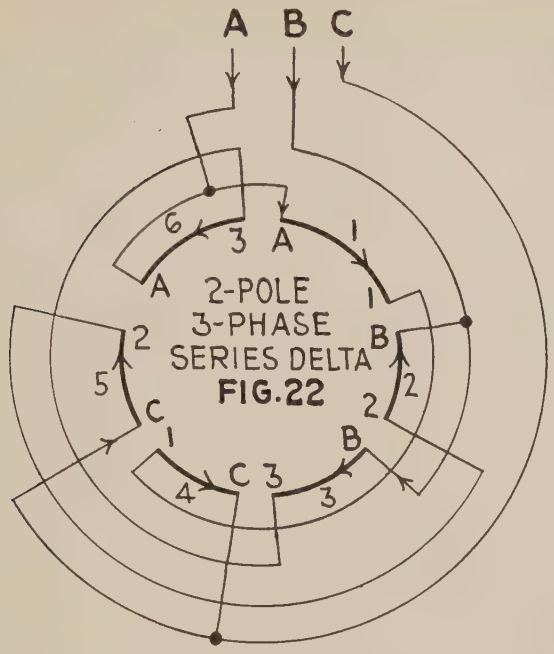

A B C
1
6
B A
2
2-POLE
3-PHASE
5
2-PARALLEL STAR C
FIG.21
B
C
A
4
3

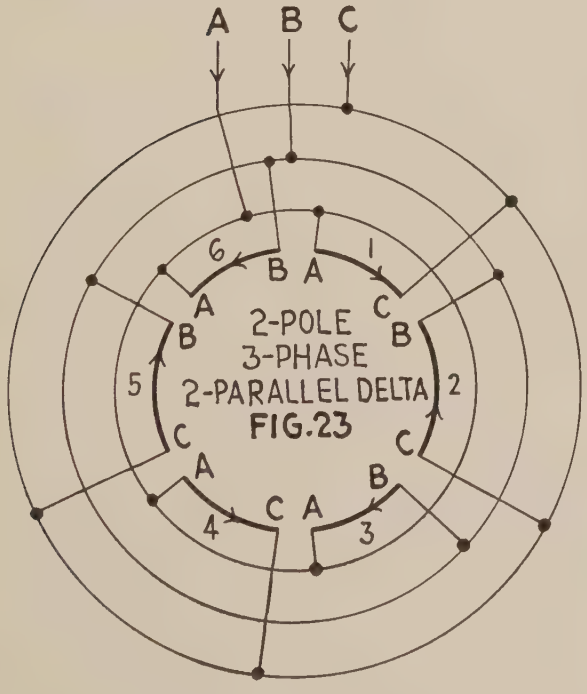
TABLE 2.—CONNECTIONS FOR ENDS OF GROUPS OF A 2-POLE, 3-PHASE WINDING

2-pole, 3-phase, top-to-top

Pole number		I						II					
Group number		1		2		3		4		5		6	
Connection	Fig. No.	T-B		T-B		T-B		T-B		T-B		T-B	
Series star	20	A	1	*	2	B	3	*	1	C	2	*	3
2-parallel star	21	"	*	"	C	"	*	"	A	"	*	"	B
Series delta	22	A	1	B	2	B	3	C	1	C	2	A	3
2-parallel delta	23	"	C	"	C	"	A	"	A	"	B	"	B

Connect together group ends having the same number or letter. Letters indicate the line leads. A star connection is shown by (*).


A B C
6
3
A
1
A
1
2-POLE
3-PHASE
SERIES DELTA
FIG.22
2
B
5
2
C
1
2
B
C
3
4
3


A B C
6
B
A
1
A
C
B
2-POLE
3-PHASE
2-PARALLEL DELTA
FIG.23
5
2
C
C
A
B
C
A
4
3

CHAPTER IX

FOUR-POLE, TWO-PHASE DIAGRAMS AND CONNECTING TABLES

This chapter covers windings for 2-phase, 4-pole stators, giving five diagrams, two connecting tables and two coil grouping charts covering both long and short jumper types. It will be noticed that the same 4-parallel connection diagram (Fig. 28) is used for both top-to-top (*T-T*) and top-to-bottom (*T-B*) diagrams.

To change a series *T-T* winding to 2-parallel, *T-T*, consult Figs. 24 and 25, also Table 3. These show that jumpers 3 and 4 are opened and the top of group 3 connected to A_2 line, top of group 5 to *A* line, and top of group 4 to B_2, top of group 6 to the *B* line.

To change a series *T-B* to 2-parallel, *T-B*, use Figs. 26 and 27 and Table 4 (*T-B*). Here we find that the short reversing jumpers 5 and 6 are cut open and the bottom of group 5 connects to the A_2 line, bottom of group 6 to B_2, bottom of group 7 to *A* and bottom of group 8 to the *B* line.

To change a series or 2-parallel *T-T* or *T-B* connection, to 4-parallel, cut open all jumpers and connect the ends as shown in Tables 3 and 4.

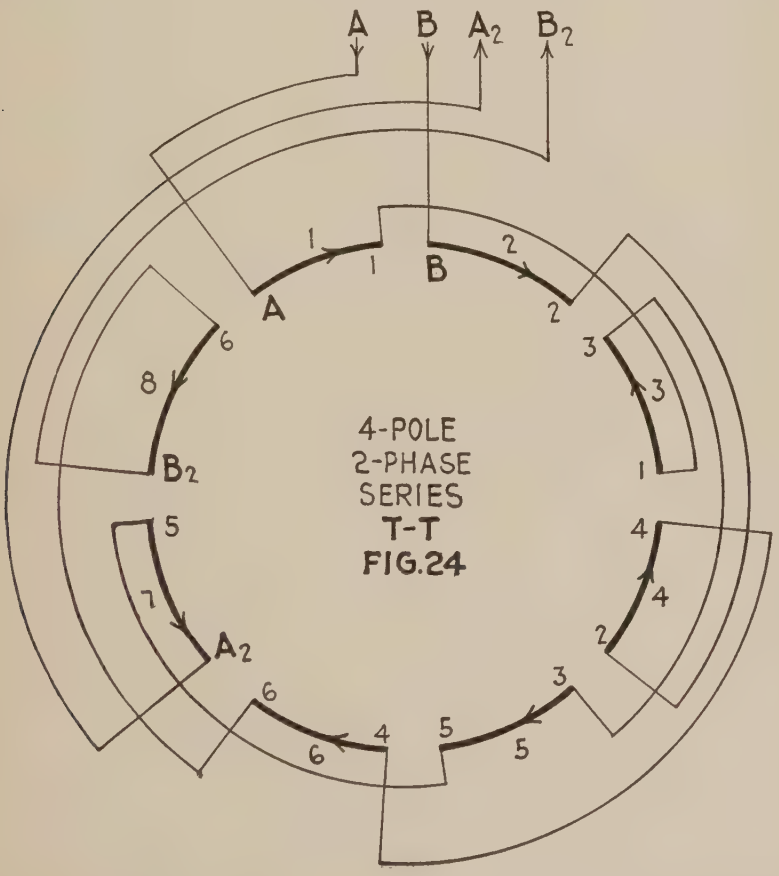
In changing a *T-B* connection to *T-T*, quite often when changing an odd grouping motor from one voltage to another, we find that the grouping will not allow a *T-B*, 2-parallel connection, but the correct combination can be had with a *T-T*, 2-parallel connection. For example: Consider a series *T-B* connection (Fig. 26) which it is desired to change to 2-parallel. The grouping will not permit a 2-parallel *T-B* connection but a 2-parallel, *T-T*, will. Then consult Figs. 26 and 28 and Tables 3 and 4, comparing the first line in the *T-B* Table 4 with the second line in *T-T* Table 3, we find groups 1 and 2 require no change, tops of groups 3-4 no change, bottom of groups 5, 6, 7, 8 no change. Jumpers 1, 2, 3, 4 are then cut open and the bottom of group 3 connected to the bottom of group 1. Bottom of group 4 is connected to bottom of group 2, then top of group 5 to *A* the line and top of group 6 to the *B* line.

This shows how the tables and diagrams are applicable to most any practical problem.

TABLE 3.—CONNECTIONS FOR ENDS OF GROUPS FOR 4-POLE, 2-PHASE, *T-T* WINDING

4-pole, 2-phase, top-to-top. See Figs. 24, 25 and 28

Pole No.		I				II				III				IV			
Group No.		1		2		3		4		5		6		7		8	
	Fig.	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	24	A	1	B	2	3	1	4	2	3	5	4	6	A_2	5	B_2	6
2-parallel	25	"	"	"	"	A_2	"	B_2	"	A	"	B	"	"	"	"	"
4-parallel	28	"	A_2	"	B_2	A_2	A	B_2	B	A	A_2	B	B_2	"	A	"	B



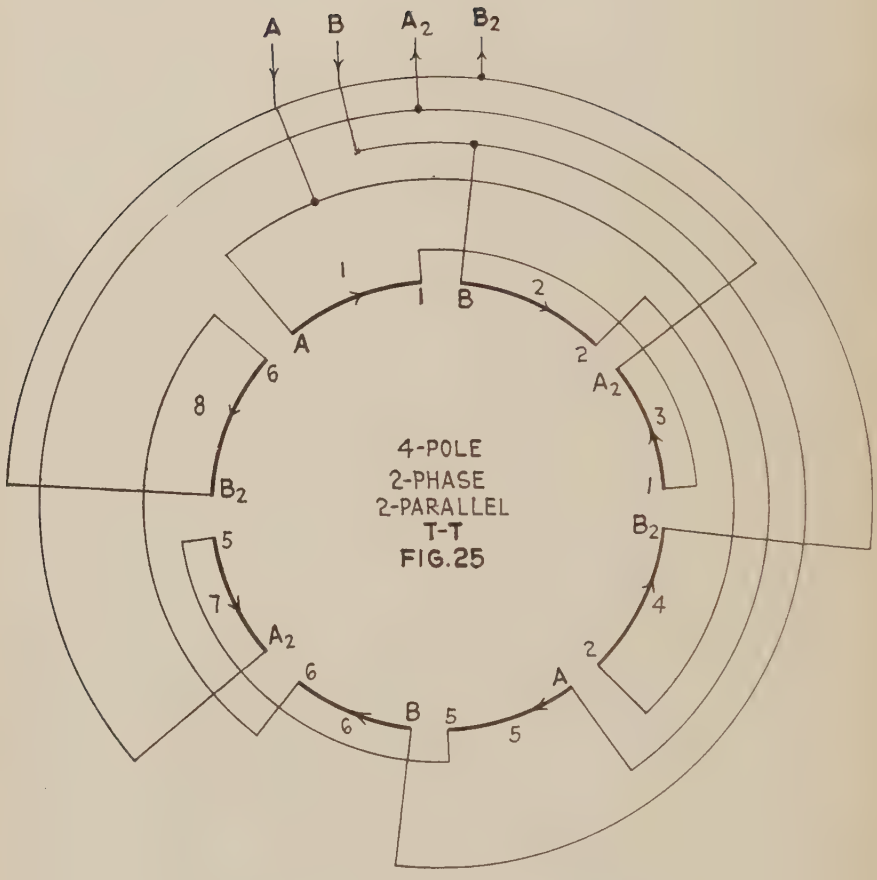

A
B
A2
B2
1
1
B
2
2
A2
3
1
B2
4
2
A
5
5
B
6
6
A2
7
5
B2
8
6
A
4-POLE
2-PHASE
2-PARALLEL
T-T
FIG. 25

CHART C.—UNEQUAL COIL GROUPING FOR 4-POLE, 2-PHASE WINDING

4-pole, 2-phase, top-to-top. See Figs. 24, 25 and 28

Coils	Group numbers							
	1	2	3	4	5	6	7	8
12	1	1	2	2	1	1	2	2
36	4	4	5	5	4	4	5	5
54	7–1	6	7	7	6	7–1	7	7
60	7	7	8	8	7	7	8	8
62	8–1	7	8	8	7	8–1	8	8
84	10	10	11	11	10	10	11	11
86	11–1	10	11	11	10	11–1	11	11
90	12–1	11	11	11	11	12–1	11	11
108	13	13	14	14	13	13	14	14
135	16	17–1	17	17	17–1	17–1	17	17
150	19–1	18	19	19	18	19–1	19	19
156	19	19	20	20	19	19	20	20
180	22	22	23	23	22	22	23	23

4-pole, 2-phase, top-to-bottom. See Figs. 26, 27 and 28

12	1	2	2	1	2	1	1	2
36	4	5	5	4	5	4	4	5
54	7–1	7	7	6	7	7–1	6	7
60	7	8	8	7	8	7	7	8
62	8–1	8	8	7	8	8–1	7	8
84	10	11	11	10	11	10	10	11
86	12–1	11	11	11	11	12–1	11	11

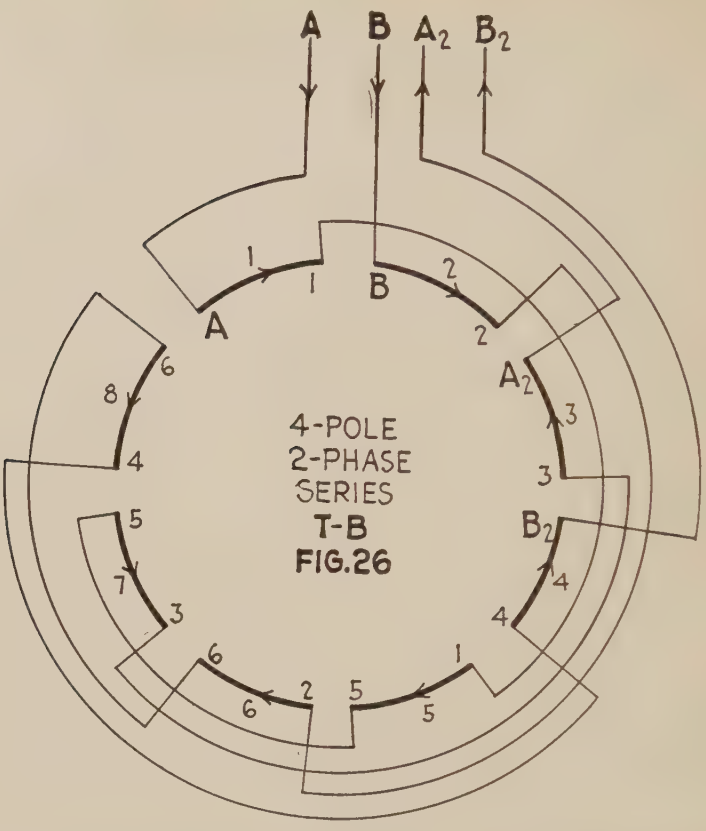


TABLE 4.—CONNECTIONS FOR ENDS OF GROUPS FOR 4-POL. 2-PHASE, *T-B* WINDING

4-pole, 2-phase, top-to-bottom. See Figs. 26, 27 and 28

Pole No.		I		II		III		IV	
Group No.		1	2	3	4	5	6	7	8
	Fig.	T B	T B	T B	T B	T B	T B	T B	T B
Series	26	A 1	B 2	A_2 3	B_2 4	1 5	2 6	3 5	4 6
2-parallel	27	" "	" "	" "	" "	" A_2	" B_2	" A	" B
4-parallel	28	" A_2	" B_2	" A	" B	A A_2	B B_2	A_2 A	B_2 B

A
B
A2
B2
4-POLE
2-PHASE
2-PARALLEL
T-B
FIG.27
4-POLE
2-PHASE
4-PARALLEL
T-T AND T-B
FIG.28

CHAPTER X

FOUR-POLE, THREE-PHASE, STAR DIAGRAMS AND CONNECTING TABLES

This chapter covers only the star (Y) type of connections for 4-pole, 3-phase windings, although the coil grouping charts are to be used for the delta winding for Chapter XI (4-pole, 3-phase, delta). The two coil grouping charts give the arrangement of coils for odd groupings; one table for *T-T* and another for *T-B* diagrams.

To change a series star *T-T* to a 2-parallel, star *T-T*, use Figs. 29 and 30, also Table 5, which shows that jumpers 2, 5, 7 are cut open, and the tops of groups 2, 4, 6 connected to the star ring and top of group 5 to the *B* line, top of group 7 to the *A* line, top of group 9 to the *C* line.

To change a 4-parallel connection to a series, it is better to remove all jumpers and leads, etc. and connect up new. Compare Figs. 29 and 33.

It is also possible to change from a *T-B* type of connection to a *T-T* as explained in Chapter IX for the 2-phase windings. Just pick out the two diagrams and tables and note where a change occurs. (Figs. 30 and 31, Tables 5 and 6.)

To change a series-star connection to a corresponding type series-delta connection, pick out the respective diagrams (as Figs. 29 and 34) and (Tables 5 and 7) and compare groups. The *T-T* series-star Table 5 shows a star connection at tops of groups 8, 10 and 12 and Table 7, *T-T*, series-delta, shows that group 8 connects to the *C* line, top of group 10 to the *B* line and top of group 12 to the *A* line. All that is necessary is to cut open the star connections and connect the top to the proper line lead.

A series-star *T-B* connection can be changed to a series or 2-parallel delta *T-T* connection or a *T-T* to a delta *T-B*, etc., by picking out the proper figures and tables and noting the different top or bottom group letters and numbers.

CHART D.—UNEQUAL COIL GROUPING FOR 4-POLE, 3-PHASE, STAR AND DELTA WINDING

4-pole, 3-phase, top-to-top. For star see Figs. 29, 30 and 33. For delta see Figs. 34, 35 and 38

Coils	Group numbers											
	1	2	3	4	5	6	7	8	9	10	11	12
18	2	1	2	1	2	1	2	1	2	1	2	1
54	4	5	4	5	4	5	4	5	4	5	4	5
62	6–1	5	5	5	5	5	5	6–1	5	5	5	5
80	6	7	7–1	7	6	7	7–1	7	6	7	6	7
86	7	7	8–1	7	7	7	8–1	7	7	7	7	7
90	7	8	7	8	7	8	7	8	7	8	7	8
104	8	9	9–1	9	8	9	9–1	9	8	9	8	9
128	10	11	11–1	11	10	11′	11–1	11	10	11	10	11
135	12–1	11	11	11	12–1	11	11	11	12–1	11	11	11
150	12	13	12	13	12	13	12	13	12	13	12	13
160	14–1	13	13	13	14–1	13	13	13	14–1	13	13	14–1

4-pole, 3-phase, top-to-bottom. For star, see Figs. 31, 32 and 33. For delta see Figs. 36, 37 and 38

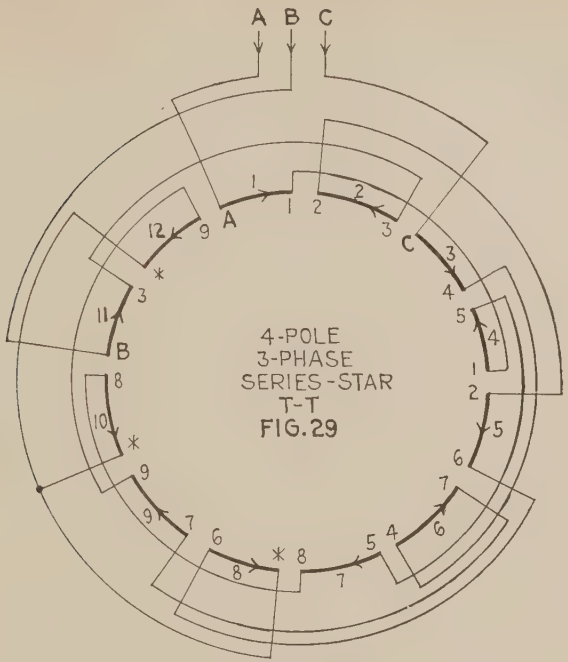
18	2	1	2	1	2	1	1	2	1	2	1	2
54	4	5	4	5	4	5	5	4	5	4	5	4
62	6–1	5	5	5	5	5	5	6–1	5	5	5	5
80	6	7	7–1	7	6	7	7	7–1	7	6	7	6
86	7	7	8–1	7	7	7	8–1	7	7	7	7	7
90	7	8	7	8	7	8	8	7	8	7	8	7
104	8	9	9–1	9	8	9	9	9–1	9	8	9	8
128	10	11	11–1	11	10	11	11	11–1	11	10	11	10
135	12–1	11	11	11	12–1	11	11	11	12–1	11	11	11
150	12	13	12	13	12	13	13	12	13	12	13	12
160	14–1	13	13	13	14–1	13	13	13	14–1	13	13	14–1

TABLE 5.—CONNECTIONS FOR ENDS OF GROUPS FOR 4-POLE, 3-PHASE, STAR *T-T* WINDING

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is shown by (*)

4-pole, 3-phase, star, top-to-top. See Figs. 29, 30 and 33

Pole No.		I						II						III						IV			
Group No.		1		2		3		4		5		6		7		8		9		10		11		12	
	Fig.	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	29	A	1	2	3	C	4	5	1	2	6	7	4	5	8	*	6	7	9	*	8	B	3	*	9
2-parallel	30	"	"	*	"	"	"	*	"	B	"	*	"	A	"	*	"	C	"	*	"	"	"	*	"
4-parallel	33	"	*	*	B	"	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	"	*	*	C


A B C
4-POLE
3-PHASE
SERIES-STAR
T-T
FIG.29

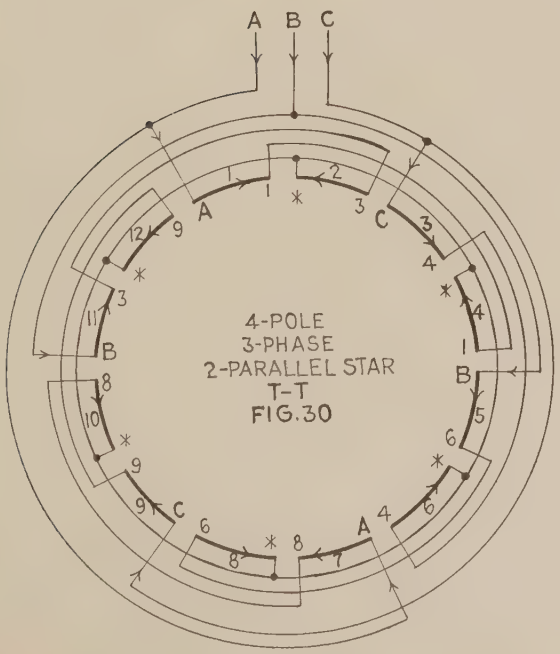
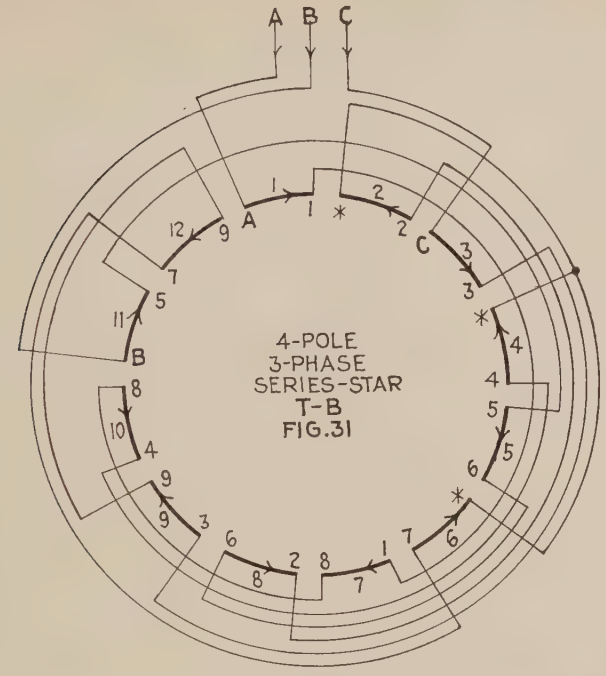
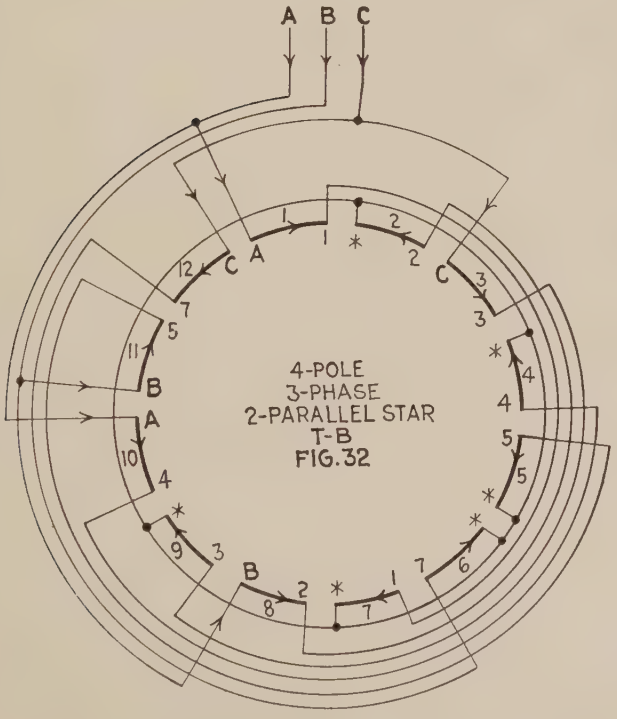

A B C
4-POLE
3-PHASE
2-PARALLEL STAR
T-T
FIG.30

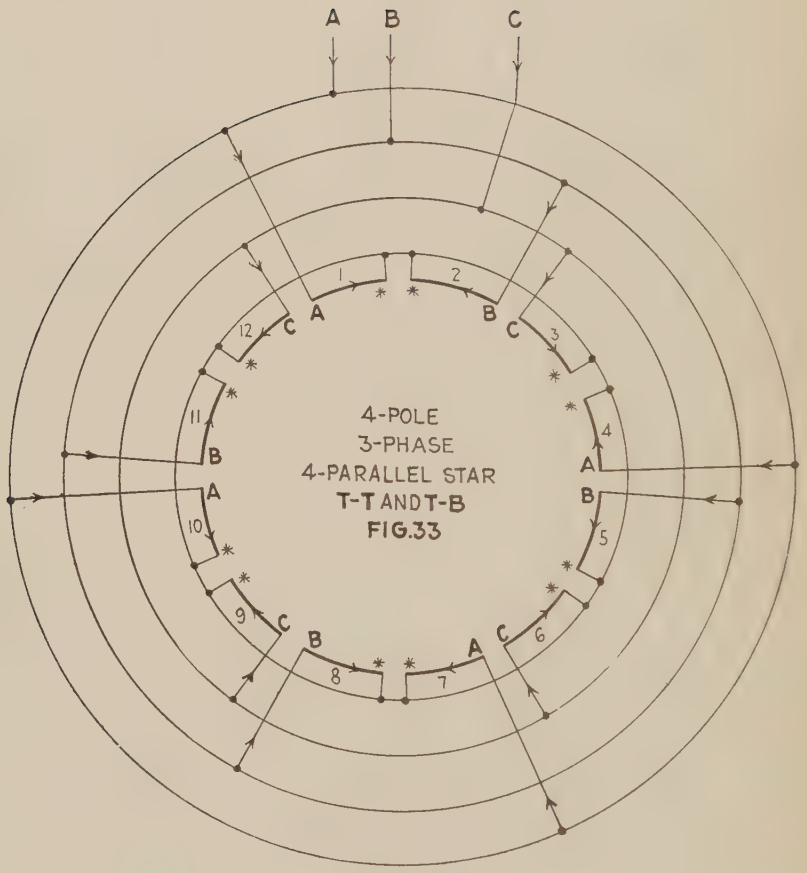
TABLE 6.—CONNECTIONS FOR ENDS OF GROUPS FOR 4-POLE, 3-PHASE, STAR *T-B*, WINDING

4-pole, 3-phase, star, top-to-bottom. See Figs. 31, 32 and 33

Pole No.		I						II						III						IV					
Group No.		1		2		3		4		5		6		7		8		9		10		11		12	
	Fig.	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	31	A	1	*	2	C	3	*	4	5	6	*	7	1	8	2	6	3	9	4	8	B	5	7	9
2-parallel	32	"	"	"	"	"	"	"	"	"	*	"	"	"	*	"	B	"	*	"	A	"	"	"	C
4-parallel	33	"	*	"	B	"	*	"	A	B	*	"	C	A	*	*	B	C	*	*	A	"	*	*	C


A B C
4-POLE
3-PHASE
SERIES-STAR
T-B
FIG.31


A B C
4-POLE
3-PHASE
2-PARALLEL STAR
T-B
FIG.32


A
B
C
1
2
3
4
5
6
7
8
9
10
11
12
4-POLE
3-PHASE
4-PARALLEL STAR
T-T AND T-B
FIG. 33

CHAPTER XI

FOUR-POLE, THREE-PHASE, DELTA DIAGRAMS AND CONNECTING TABLES

For the odd coil grouping charts see Chapter X (4-pole, 3-phase, star). To change a series-delta T-T connection to a 2-parallel delta T-T, consult Figs. 34 and 35 and Table 7, first and second lines.

The same changes as mentioned in Chapter X (3-star) can be made by consulting the diagrams and tables covering the old and desired connection.

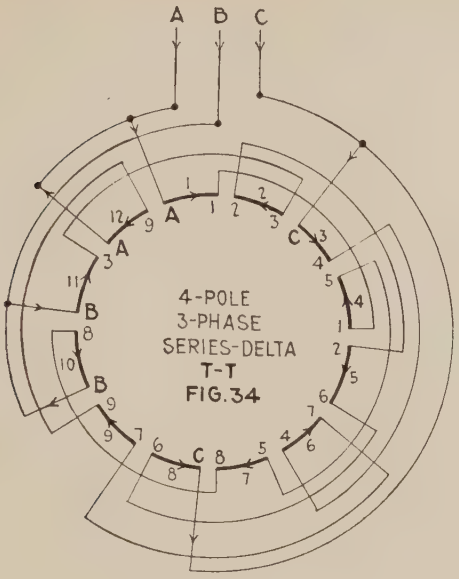
To change a series-delta, T-T connection to a series-star T-T, use Figs. 29 and 34 and Tables 5 and 7. The series delta T-T (Table 7) shows that the tops of groups 12 and 1 connect to the *A* line; tops of groups 3 and 8 to the *C* line, and tops of 10 and 11 to the *B* line, while Table 5 for the series-star T-T connection shows that only tops of groups 1, 3 and 11 connect to the *A*, *B* and *C* line and that tops of groups 8, 10 and 12 are star connected. Then cut the tops of groups 8, 10 and 12 away from their respective line leads in the series-delta diagram (Fig. 34) and connect these three tops together to form the star connection.

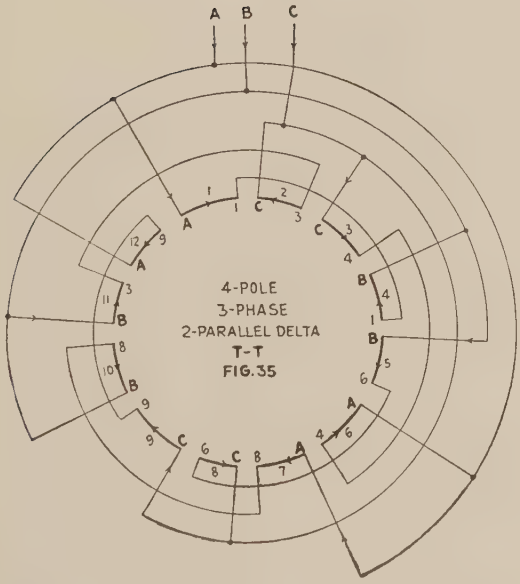
A little study of these tables and diagrams will reveal the number of different combinations that can be worked out.

TABLE 7.—CONNECTIONS FOR ENDS OF GROUPS FOR 4-POLE, 3-PHASE, DELTA T-T. WINDING

4-pole, 3-phase, delta, top-to-top. See Figs. 34, 35 and 38

Pole No.		I			II			III			IV		
Group No.		1	2	3	4	5	6	7	8	9	10	11	12
	Fig.	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B
Series	34	A 1	2 3	C 4	5 1	2 6	7 4	5 8	C 6	7 9	B 8	B 3	A 9
2-parallel	35	" "	C "	" "	" B "	B "	A "	A "	" "	" C	" "	" "	" "
4-parallel	38	" B	" B	" A	B A	B C	A C	A B	" B	C A	" A	" C	" C


A B C
4-POLE
3-PHASE
SERIES-DELTA
T-T
FIG.34


A B C
4-POLE
3-PHASE
2-PARALLEL DELTA
T-T
FIG.35

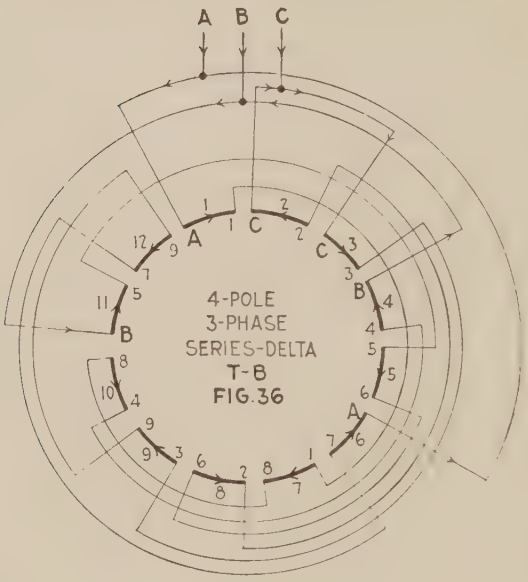
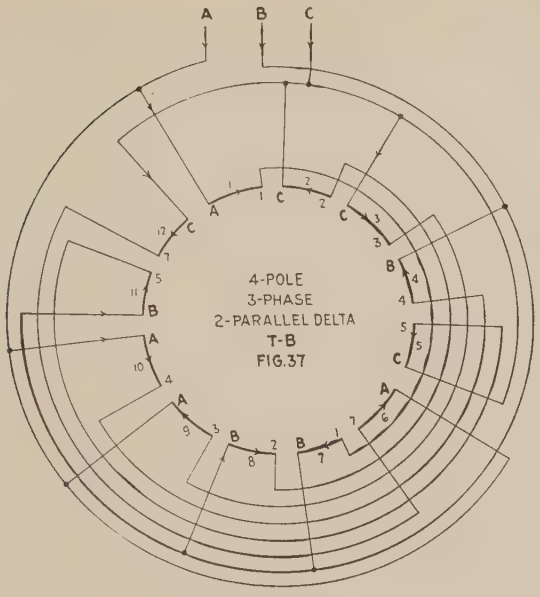
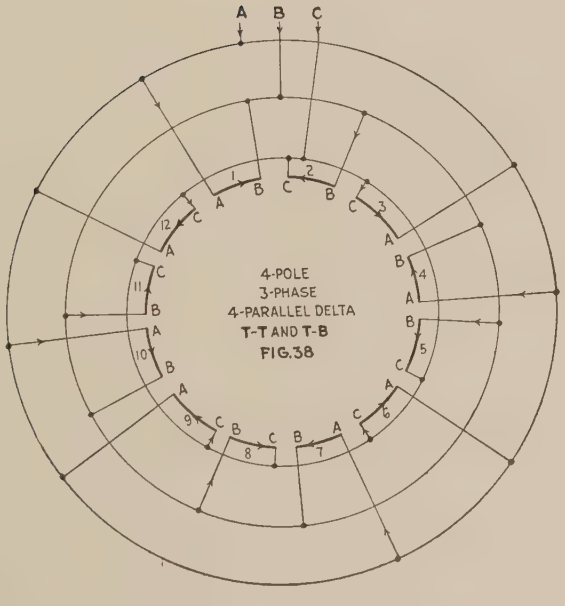


TABLE 8.—CONNECTIONS FOR ENDS OF GROUPS FOR 4-POLE, 3-PHASE, DELTA T-B, WINDING

4-pole, 3-phase, delta, top-to-bottom. See Figs. 36, 37 and 38

Pole No.		I			II			III			IV		
Group No.	1	2	3	4	5	6	7	8	9	10	11	12	
	Fig.	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B
Series	36	A 1	C 2	C 3	B 4	5 6	A 7	1 8	2 6	3 9	4 8	B 5	7 9
2-parallel	37	" "	" "	" "	" "	" C	" "	" B	" B	" A	" A	" "	" C
4-parallel	38	" B	" B	" A	" A	B C	" C	A B	C B	C A	B A	" C	A C


A B C
4-POLE
3-PHASE
2-PARALLEL DELTA
T-B
FIG.37


A B C
4-POLE
3-PHASE
4-PARALLEL DELTA
T-T AND T-B
FIG.38

CHAPTER XII

SIX-POLE, TWO-PHASE DIAGRAMS AND CONNECTING TABLES

On 6-pole, 2-phase windings, there are four connections obtainable; that is, series, 2-, 3- and 6-parallel. The diagrams will enable any reconnection desired to be easily made.

To change from a series T-T to a 3-parallel T-T connection, use the diagrams in Figs. 39 and 41 and Table 9. Compare the lines one and three. Jumpers 3, 4, 7 and 8 are cut open and the tops of groups 3 and 7 connect to the A_2 line; tops of groups 4 and 8 to the B_2 line; tops of groups 5 and 7 to the A line, and tops of groups 6 and 10 to the B line, requiring four jumpers to be cut open and the leads taped.

For changing series T-T to 2-parallel T-T, see Figs. 39 and 40, Table 9, lines 1 and 2. Note that the bottom jumpers 5 and 6 are cut and the bottom of group 5 is connected to the A_2 line; bottom of group 6 to the B_2 line; bottom of group 7 to the A, and bottom of group 8 to the B line.

A top-to-bottom diagram can also be changed over to any top-to-top diagram if the coil grouping necessitates the change. When changing from series T-B (Fig. 42, Table 10) to 2-parallel T-T (Fig. 40, Table 9) on comparing the tables, we find that it would be better to remove all jumpers and connect up new, as groups 1 and 2 are the only ones that can be left unchanged.

If the machine under consideration is connected in a different manner from any of the diagrams given, find its type; that is, T-B or T-T series or parallel, etc. Then select two figures in the proper chapter and note the changes required. This information can then be applied to the winding as all connections follow the principles outlined in previous chapters.

Chart E.—Unequal Coil Grouping for 6-pole, 2-phase, Winding

6-pole, 2-phase, top-to-top connections. See Figs. 39, 40, 41 and 42

Coils	Group numbers											
	1	2	3	4	5	6	7	8	9	10	11	12
18	2	2	1	1	2	2	1	1	2	2	1	1
*18	2–1	1	2	2	1	1	1	2–1	2	2	1	1
54	4	4	5	5	4	4	5	5	4	4	5	5
*54	5–1	4	5	5	4	4	4	5–1	5	5	4	4
62	6–1	5	5	5	5	5	5	6–1	5	5	5	5
80	6	7	7	6	7	7k	6	7	7	6	7k	7
86	8–1	7	7	7	7	7	7	8–1	7	7	7	7
90	7	7	8	8	7	7	8	8	7	7	8	8
*90	8–1	7	8	8	7	7	7	8–1	8	8	7	7
104	8	9	9	9k	9	8	8	9	9k	9	9	8
128	10	11	11	11k	11	10	10	11	11k	11	11	10
135	12k	11	11	11	12–1	11	11	12k	11	11	11	11
150	12	12	13	13	12	12	13	13	12	12	13	13
*150	13–1	12	13	13	12	12	12	13–1	13	13	12	12
160	14k	13	13	14k	13	13	14k	13	13	14k	13	13

k A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

* Use this line where an asterisk (*) appears in the Main Table (see pages 8–9).

Tables 9 and 10.—Connections for Ends of Groups of 6-pole, 2-phase Winding

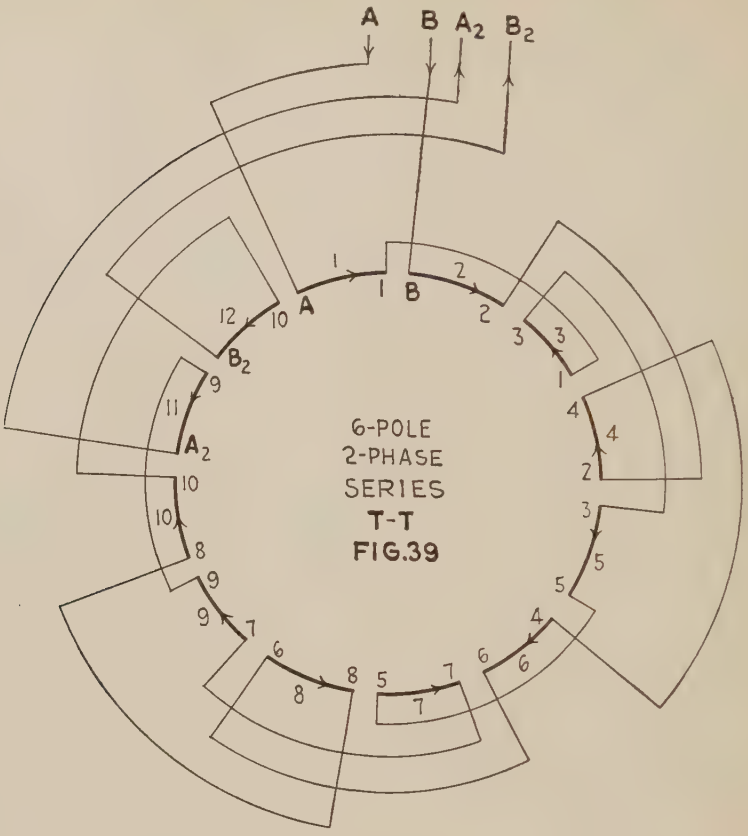
Connect together group ends having same number or letter. Line leads are indicated by letters.

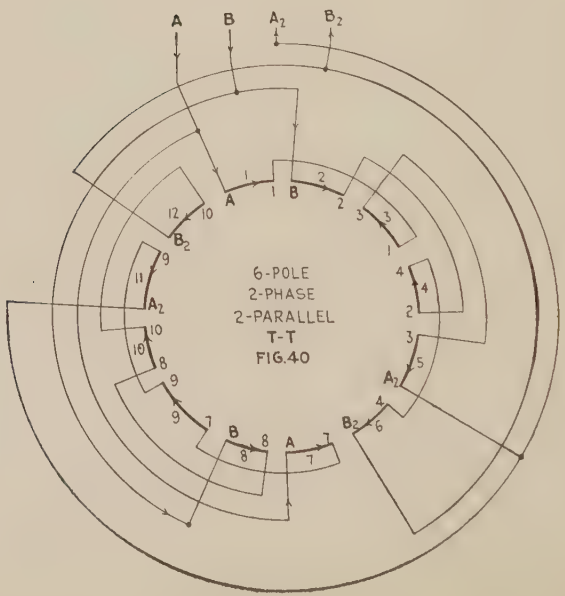
6-pole, 2-phase, top-to-top. See Figs. 39, 40, 41, 45

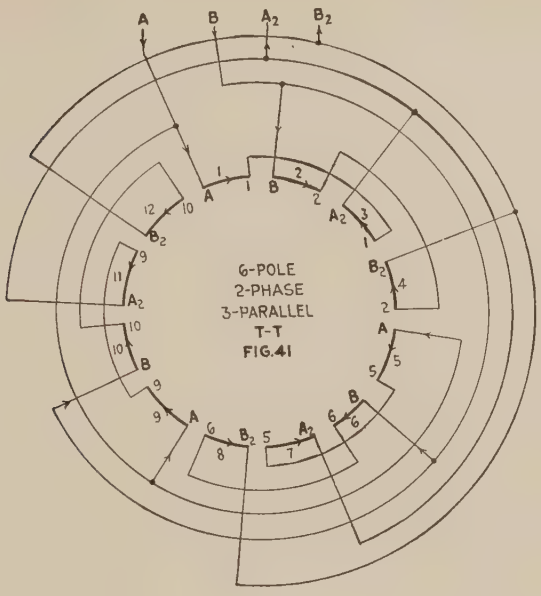
Pole Number		I		II		III		IV		V		VI	
Group No.		1	2	3	4	5	6	7	8	9	10	11	12
	Fig.	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B
Series	39	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	A_2 9	B_2 10
2-parallel	40	" "	" "	" "	" "	" A_2	" B_2	" A	" B	" "	" "	" "	" "
3-parallel	41	" "	" "	A_2 "	B_2 "	A 5	B 6	A_2 5	B_2 6	A "	B "	" "	" "
6-parallel	45	" A_2	" B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	" A	" B

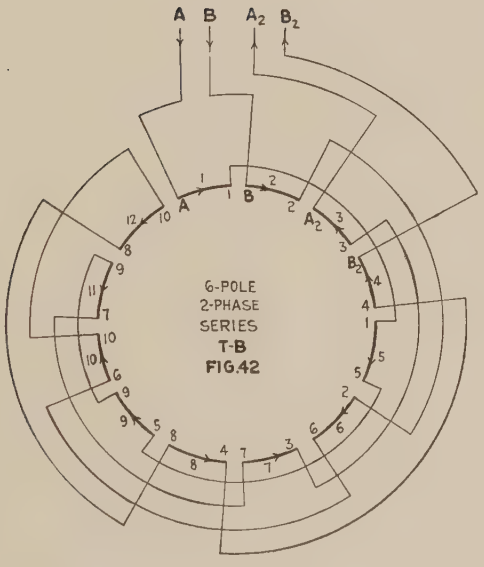
6-pole, 2-phase, top-to-bottom. See Figs. 42, 43, 44, 45

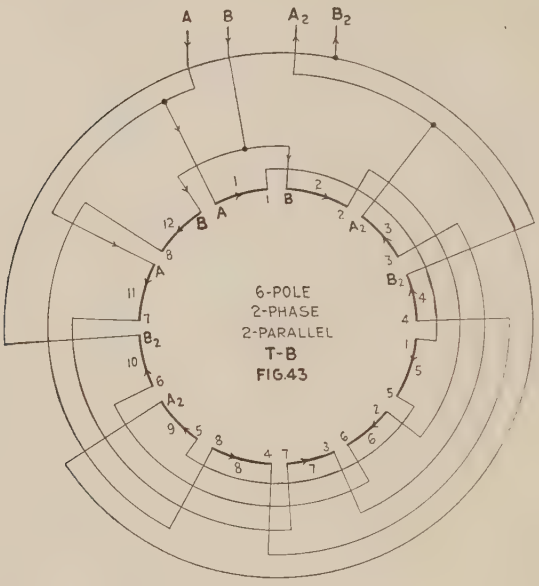
Series	42	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	7	4	8	5	9	6	10	7	9	8	10
2-parallel	43	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	A_2	"	B_2	"	A	"	B
3-parallel	44	"	"	"	"	"	"	"	"	A_2	"	B_2	"	A	"	B	A	9	B	10	A_2	9	B_2	10		
6-parallel	45	"	A_2	"	B_2	"	A	"	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

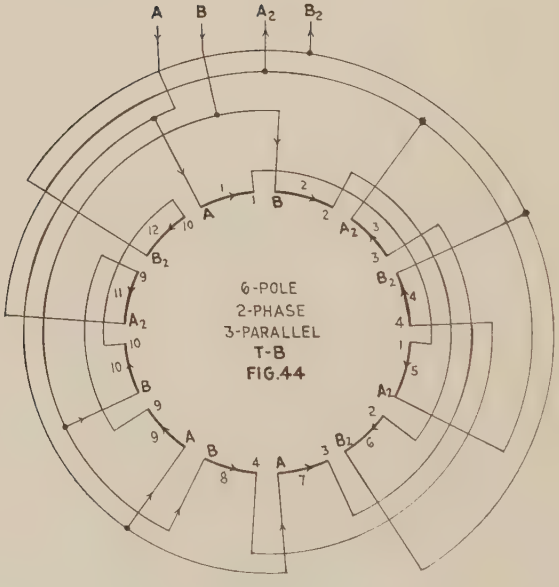

A
B
A2
B2
6-POLE
2-PHASE
SERIES
T-T
FIG.39

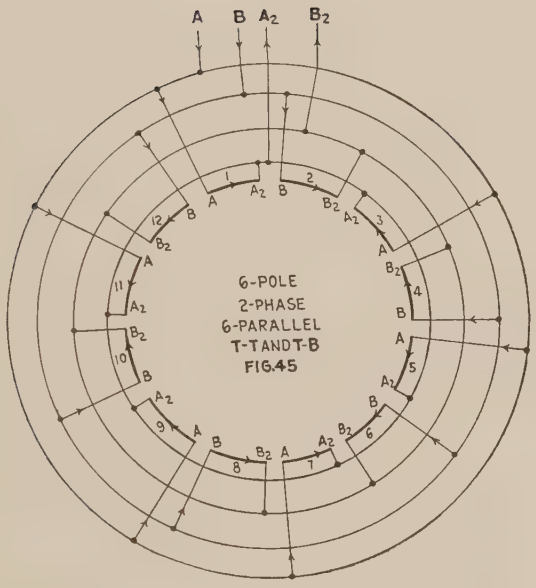

A
B
A2
B2
6-POLE
2-PHASE
2-PARALLEL
T-T
FIG.40


A
B
A2
B2
6-POLE
2-PHASE
3-PARALLEL
T-T
FIG.41


A
B
A2
B2
6-POLE
2-PHASE
SERIES
T-B
FIG.42


A
B
A2
B2
6-POLE
2-PHASE
2-PARALLEL
T-B
FIG.43


A
B
A2
B2
6-POLE
2-PHASE
3-PARALLEL
T-B
FIG.44


A
B
A2
B2
6-POLE
2-PHASE
6-PARALLEL
T-TANDT-B
FIG.45

CHAPTER XIII

SIX-POLE, THREE-PHASE, STAR DIAGRAMS AND CONNECTING TABLES

With a 6-pole, 3-phase winding there are eight conections possible that will give a voltage change; namely, series, 2-, 3- and 6-parallel star and a change to series, 2-, 3- and 6-parallel delta or vice versa.

To change from series star T-T (Fig. 46) to 6-parallel star T-T (Fig. 52) use Table 11, line 1 and 4 which shows jumpers 6, 8 and 10 are cut open and that the bottom of groups 5, 7 and 9 become star leads and the bottom of group 10 to the *A* line, bottom of group 12 to the *C* line, and bottom of group 8 to the *B* line.

To change a series star T-B winding (Fig. 49, Table 12) to a 2-parallel T-T winding (Fig. 47, Table 11) we find that the number of changes involved are such that it would be quicker and cheaper to cut off all jumpers and leads and connect up as a new winding. The line leads can be left attached to groups 1, 3 and 17 so that the old lead cables can be used and tops connected to the other three groups.

To change a series-star T-T winding (Fig. 46) to a series-delta T-T winding (Fig. 53) use Tables 11 and 13 which show the only change is to cut open the star and connect the top of groups 14 to the *C* line, top of group 16 to the *B* line and the top of group 18 to the *A* line.

Any other change can be checked by consulting the proper diagrams and the lines in the respective tables for connections of ends of groups.

CHART F.—UNEQUAL COIL GROUPING FOR 6-POLE, 3-PHASE, STAR AND DELTA WINDINGS

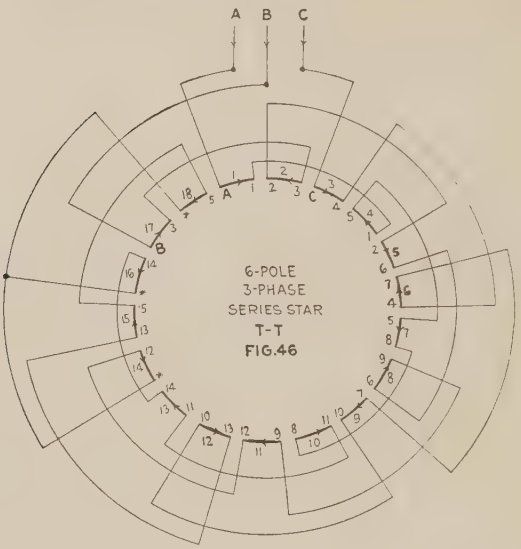
6-pole, 3-phase, top-to-top and top-to-bottom, see Figs. 46 to 59

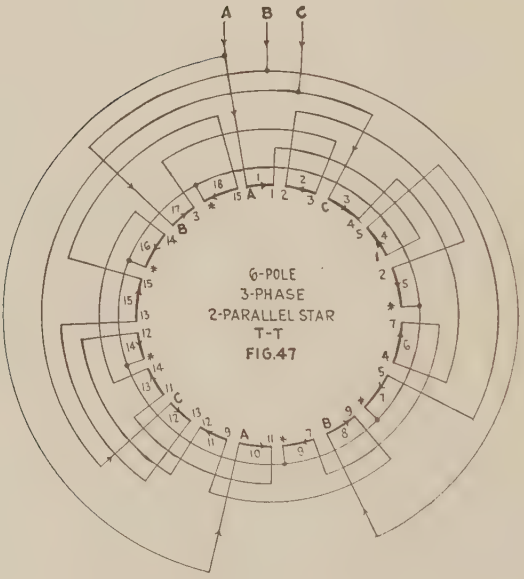
Coils	Group numbers																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
24	2	1	1	1	1	2	1	2	1	2	1	1	1	1	2	1	2	1
48	2	3	3	3	3	2	3	2	3	2	3	3	3	3	2	3	2	3
60	4	3	3	3	3	4	3	4	3	4	3	3	3	3	4	3	4	3
62	4	3	3	3	3	4	4–1	4	3	4	3	3	3	3	4	3	4	4–1
80	5	4	4	4	4	5	5–1	5	4	5	4	4	4	4	5	4	5	5–1
84	4	5	5	5	5	4	5	4	5	4	5	5	5	5	4	5	4	5
86	4	5	5	5	5	5–1	5	4	5	4	5	5	5	5	4	5	5–1	5
96	6	5	5	5	5	6	5	6	5	6	5	5	5	5	6	5	6	5
104	5	6	6	6	6	6–1	6	5	6	5	6	6	6	6	5	6	6–1	6
120	6	7	7	7	7	6	7	6	7	6	7	7	7	7	6	7	6	7
128	7	7	7	7	7	8–1	7	7	7	7	7	7	7	7	7	8–1	7	7
†135	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7
†135*	8–1	8	8	7	7	7	8	8–1	8	7	7	7	8	8	8–1	7	7	7
150	9	8	8	8	8	9	8	9	8	9	8	8	8	8	9	8	9	8
156	8	9	9	9	9	8	9	8	9	8	9	9	9	9	8	9	8	9
†160	9–1	9	9	9	9	9k	9	8	9	9k	9	9	9	9	8	9	9k	9
*160	9–1	9	9	9	9	9–1	9	8	9	9–1	9	9	9	9	8	9	9–1	9
168	10	9	9	9	9	10	9	10	9	10	9	9	9	9	10	9	10	9
240	14	13	13	13	13	14	13	14	13	14	13	13	13	13	14	13	14	13

† These groupings are not for top-to-bottom connection.

k A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

* Use this line where an asterisk (*) appears in the Main Table (see pages 8–9).


A B C
6-POLE
3-PHASE
SERIES STAR
T-T
FIG.46


A B C
6-POLE
3-PHASE
2-PARALLEL STAR
T-T
FIG.47

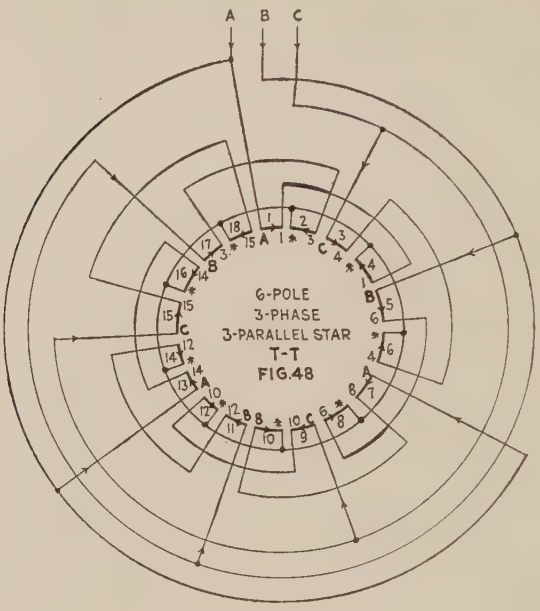
TABLES 11 AND 12.—CONNECTIONS FOR ENDS OF GROUPS FOR 6-POLE, 3-PHASE STAR T-T AND T-B WINDINGS

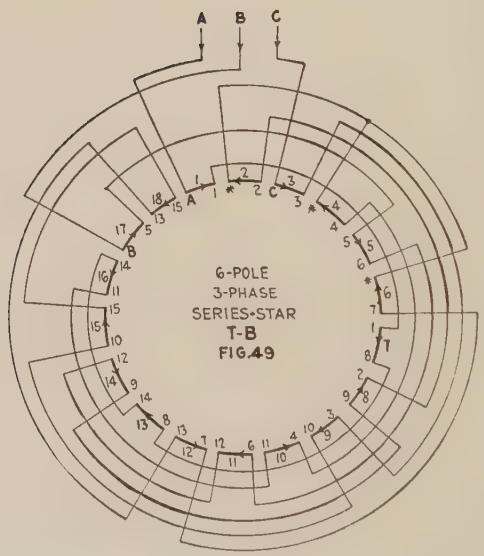
6-pole, 3-phase, Star, Top-to-Top. See Figs. 46, 47, 48 and 52

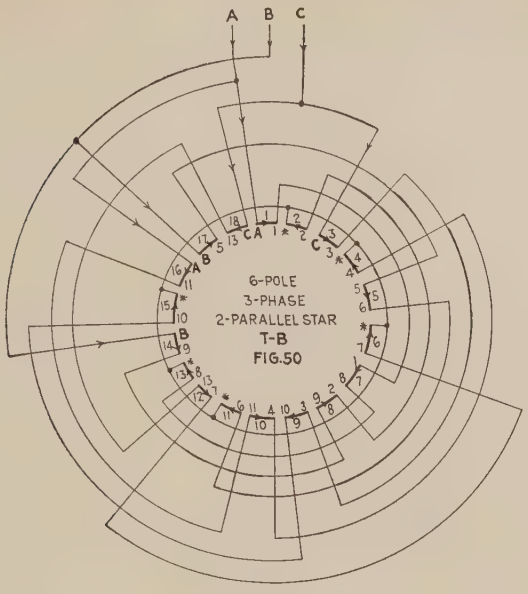
Pole number		I			II			III			IV			V			VI		
Group number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Fig.	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B
Series	46	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	* 12	13 15	* 14	B 3	* 15
2-parallel	47	" "	" "	" "	" "	* "	" "	* "	B "	* "	A "	" "	C "	" "	" "	" "	* "	" "	" "
3-parallel	48	" "	* "	" "	* "	B "	* "	A "	* 6	C "	* 8	B "	* 10	A "	" "	C "	* "	" "	" "
6-parallel	52	" *	* B	" *	* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	" B	C *	" A	" *	" C

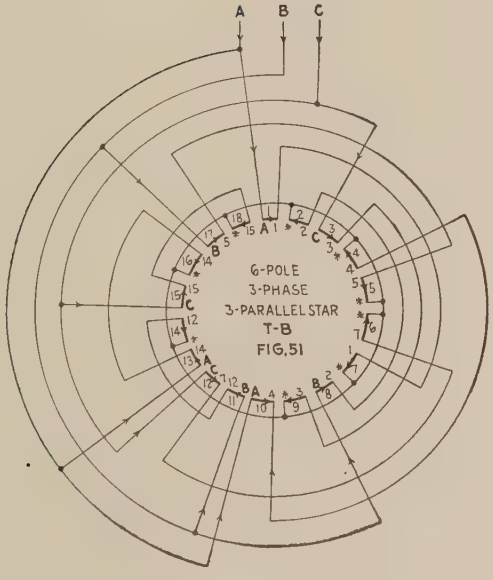
6-pole, 3-phase, Star, Top-to-Bottom. See Figs. 49, 50, 51, 52

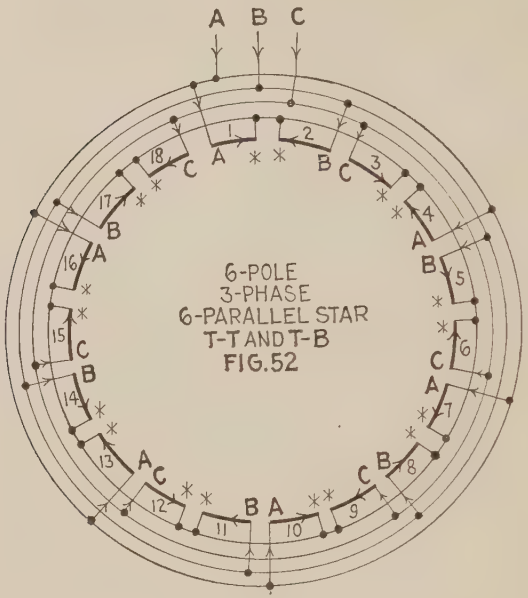
Series	49	A 1	* 2	C 3	* 4	5 6	* 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 12	10 15	11 14	B 5	13 15
2-parallel	50	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" *	" "	* "	B "	* "	A "	" "	C "
3-parallel	51	" "	" "	" "	" "	" "	* "	" "	* "	B "	* "	A B	" "	C A	" *	12 C	15 *	14 "	" *	15
6-parallel	52	" *	" B	" *	" A	B *	" C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	" *	* C

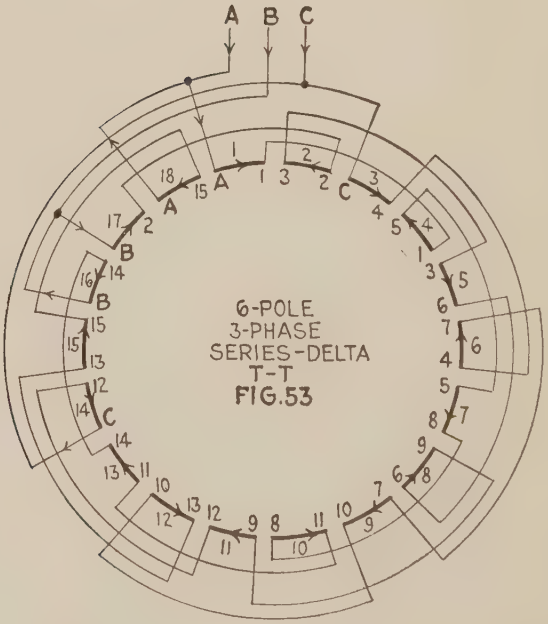

A
B
C
6-POLE
3-PHASE
3-PARALLEL STAR
T-T
FIG.48


A
B
C
6-POLE
3-PHASE
SERIES-STAR
T-B
FIG.49


A
B
C
6-POLE
3-PHASE
2-PARALLEL STAR
T-B
FIG.50


A
B
C
6-POLE
3-PHASE
3-PARALLEL STAR
T-B
FIG.51


A B C
6-POLE
3-PHASE
6-PARALLEL STAR
T-T AND T-B
FIG.52


A B C
6-POLE
3-PHASE
SERIES-DELTA
T-T
FIG.53

CHAPTER XIV

SIX-POLE, THREE-PHASE, DELTA DIAGRAMS AND CONNECTING TABLES

This chapter uses only the delta diagrams. Connecting Chart F must be consulted for odd coil groupings. By the proper selection of the diagrams and tables any possible change can be made from series delta T-T (Fig. 53) to 2-parallel delta T-T (Fig. 54 and Table 13); or from series delta to a series-star or 2-parallel star, etc.

The majority of reconnections on 6-pole windings will be from series to 2-parallel or vice versa.

TABLES 13 AND 14.—CONNECTIONS FOR ENDS OF GROUPS FOR 6-POLE, 3-PHASE DELTA WINDINGS

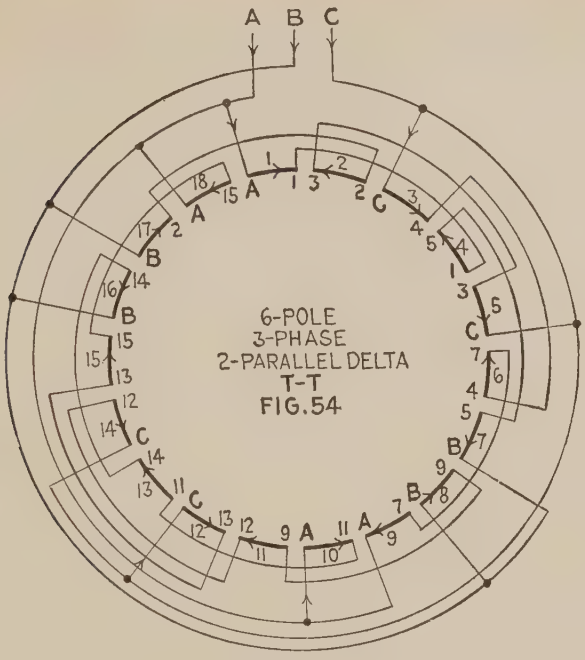
6-pole, 3-phase, Delta, Top-to-Top. See Figs. 53, 54, 55 and 59

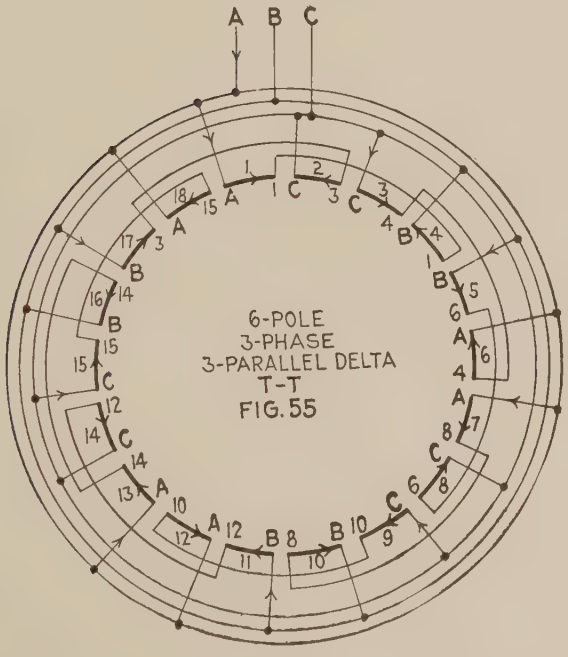
Pole number		I			II			III			IV			V			VI		
Group number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Figs.	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B
Series	53	A 1	3 2	C 4	5 1	3 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	C 12	13 15	B 14	B 2	A 15
2-parallel	54	" "	" "	" "	" "	" C	" "	" B	" B	" A	" A	" "	" C	" "	" "	" "	" "	" "	" "
3-parallel	55	" "	C 3	" "	B "	B 6	A "	A 8	C 6	C 10	B 8	B "	A 10	A "	" "	C "	" "	" 3	" "
6-parallel	59	" B	C B	" A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	" B	C A	" A	" C	" C

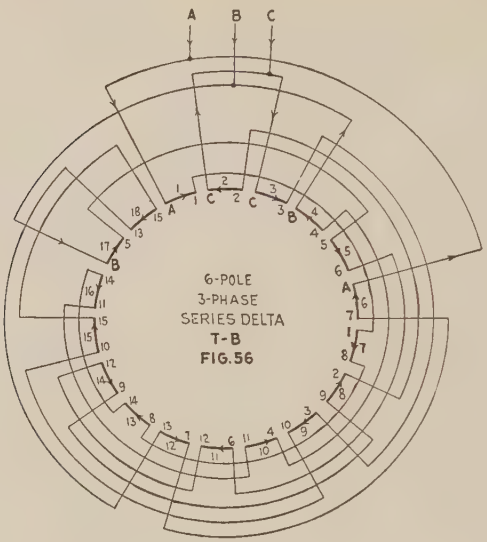
6-pole, 3-phase, Delta, Top-to-Bottom. See Figs. 56, 57, 58, 59.

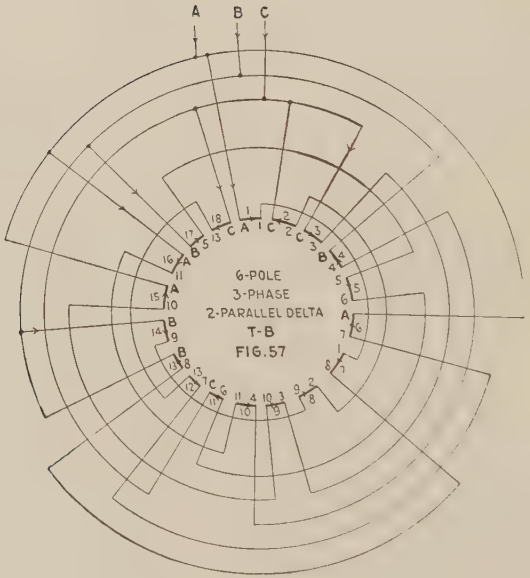
Series	56	A 1	C 2	C 3	B 4	5 6	A 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 12	10 15	11 14	B 5	13 15
2-parallel	57	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" C	" "	" B	" B	" A	" A	" "	" C
3-parallel	58	" "	" "	" "	" "	" C	" "	" B	" B	" A	" A	B 12	" C	A 14	C 12	C 15	B 14	" "	A 15
6-parallel	59	" B	" B	" A	" A	B C	" C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	" C	A C

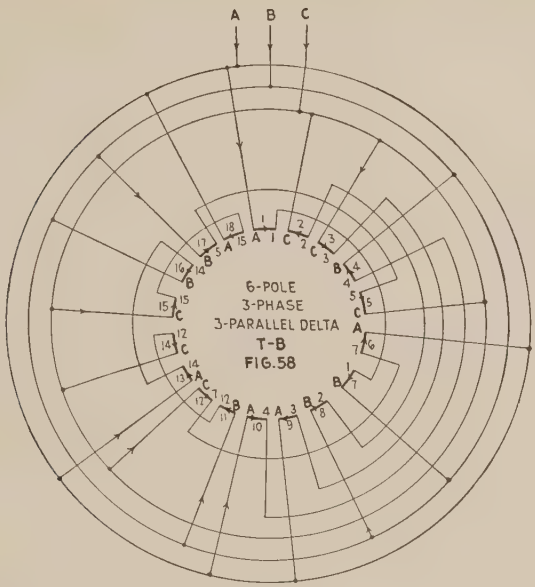
For unequal coil groupings see Chart F, Chapter 10.

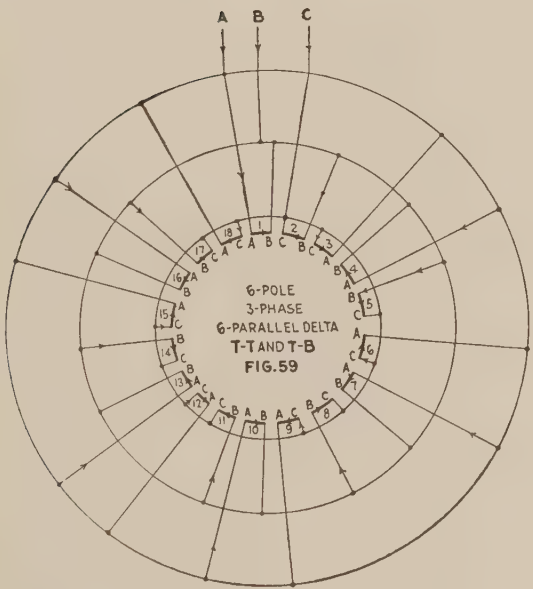

A B C
6-POLE
3-PHASE
2-PARALLEL DELTA
T-T
FIG.54


A B C
6-POLE
3-PHASE
3-PARALLEL DELTA
T-T
FIG.55


A
B
C
6-POLE
3-PHASE
SERIES DELTA
T-B
FIG.56


A
B
C
6-POLE
3-PHASE
2-PARALLEL DELTA
T-B
FIG.57


A
B
C
6-POLE
3-PHASE
3-PARALLEL DELTA
T-B
FIG.58


A
B
C
6-POLE
3-PHASE
6-PARALLEL DELTA
T-T AND T-B
FIG.59

CHAPTER XV

EIGHT-POLE, TWO-PHASE DIAGRAMS AND CONNECTING TABLES

This chapter consists of seven diagrams and three tables. The possible connections are series, 2-, 4- and 8-parallel.

A change from 2-parallel T-T (Fig. 61) to series T-T (Fig. 60) can be made by consulting Table 15. Here we find that the tops of groups 7, 8, 9 and 10 are cut from the line leads and the tops of groups 7 and 9 joined by a jumper number 7 and that the tops of group 8 and 10 are also joined by a jumper number 8. Thus the change is made by cutting open four leads and putting on two jumpers.

On changing from a series T-B (Fig. 62, Table 16) to a 4-parallel T-T connection (Fig. 62, Table 16), we find that the tops of groups 1, 2, 3 and 4 are not changed, and that the bottom of groups 1, 2, 5, 6, 9, 10, 13, 14, 15 and 16 are not changed. Jumpers number 3, 4, 7, 8, 11 and 12 are removed and the other jumpers cut open and reconnected as shown in the table.

The best method would be to take one leg of each phase circuit out at a time and make the connections as called for.

Chart G.—Unequal Coil Grouping for 8-pole, 2-phase Windings

8-pole, 2-phase, top-to-top. See Figs. 60 to 66

Coils	Group numbers															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
24	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2
36	3[k]	2	2	2	2	3[k]	2	2	3[k]	2	2	2	2	3[k]	2	2
54	4[k]	3	4–1	3	3	4[k]	3	3	4[k]	3	3	4–1	3	4[k]	3	3
60	3	4[k]	4	4	4[k]	3	4	4	3	4[k]	4	4	4[k]	3	4	4
62	3	4[k]	4	4	4[k]	4–1	4	4	4–1	4[k]	4	4	4[k]	3	4	4
72	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5
84	6[k]	5	5	5	5	6[k]	5	5	6[k]	5	5	5	5	6[k]	5	5
86	6[k]	5	6–1	5	5	6[k]	5	5	6[k]	5	5	6–1	5	6[k]	5	5
90	6–1	5	6	6	5	5	6	6	5	6–1	6	6	5	5	6	6
104	6	6	7	7	6	6	7	7	6	6	7	7	6	6	7	7
108	6	7[k]	7	7	7[k]	6	7	7	6	7[k]	7	7	7[k]	6	7	7
120	7	7	8	8	7	7	8	8	7	7	8	8	7	7	8	8
135	9[k]	8	8	8	9–1	9[k]	8	8	9[k]	9–1	8	8	9–1	9[k]	8	8
150	10[k]	9	10–1	9	9	10[k]	9	9	10[k]	9	9	10–1	9	10[k]	9	9
156	9	10[k]	10	10	10[k]	9	10	10	9	10[k]	10	10	10k	9	10	10
168	10	10	11	11	10	10	11	11	10	10	11	11	10	10	11	11
180	12[k]	11	11	11	11	12[k]	11	11	12[k]	11	11	11	11	12[k]	11	11
216	14	14	13	13	14	14	13	13	14	14	13	13	14	14	13	13

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding (see pages 8–9).

Tables 15 and 16.—Connections for Ends of Groups for 8-pole, 2-phase Windings

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is shown by (*)

Table 15.—8-pole, 2-phase, Top-to-top

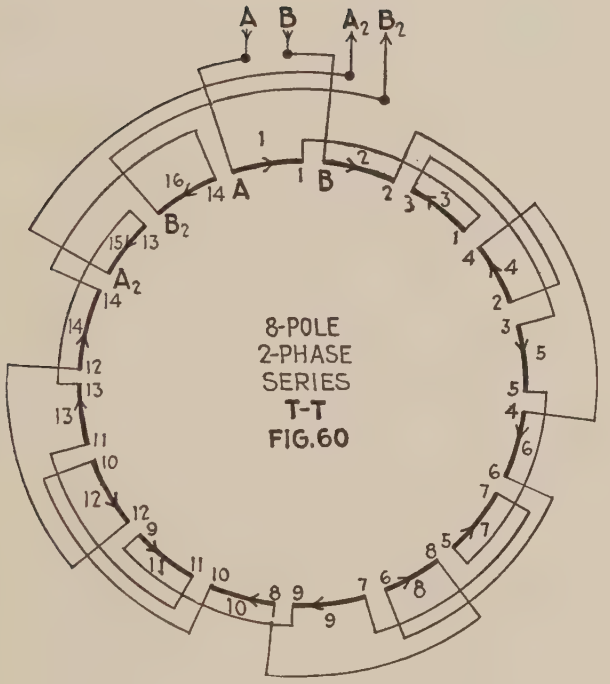
See Figs. 60, 61, 62 and 66

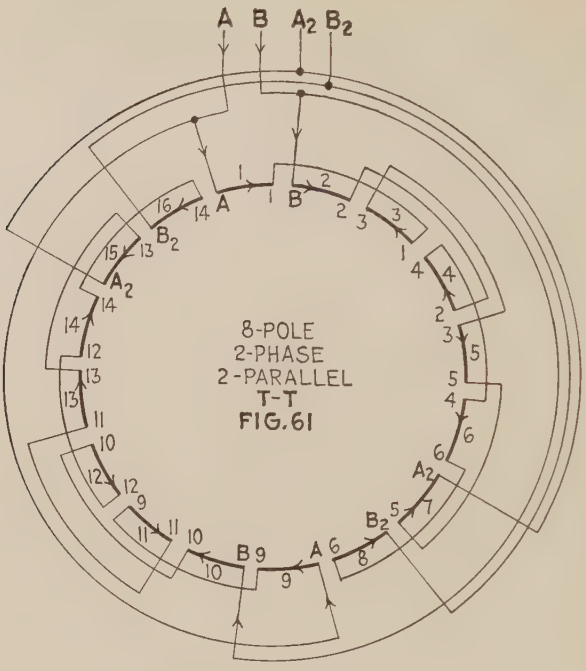
Pole number		I		II		III		IV		V		VI		VII		VIII	
Group number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Fig.	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B
Series	60	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	A_2 13	B_2 14
2-parallel	61	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B "	" "	" "	" "	" "	" "	" "
4-parallel	62	" "	" "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	" "	" "
8-parallel	66	" A_2	" B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	" A	" B

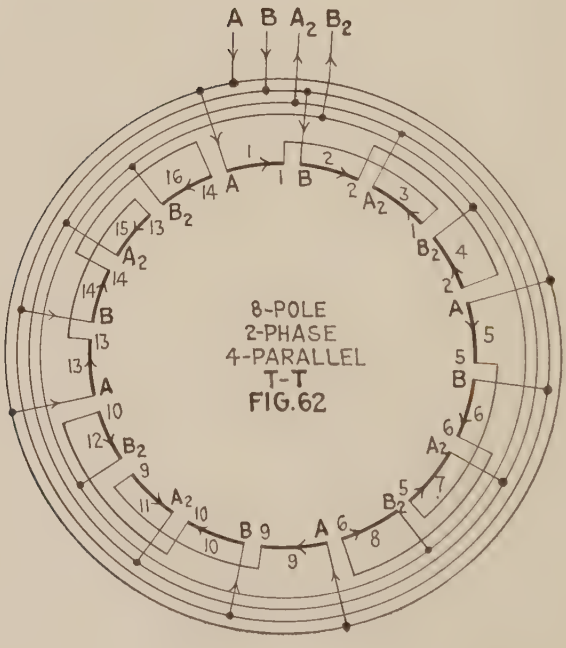
Table 16.—8-pole, 2-phase, Top-to-bottom

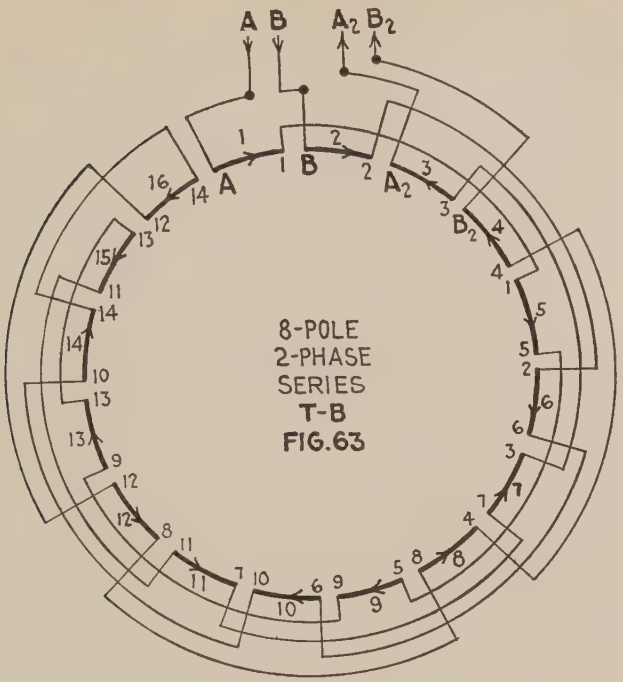
See Figs. 63, 64, 65 and 66

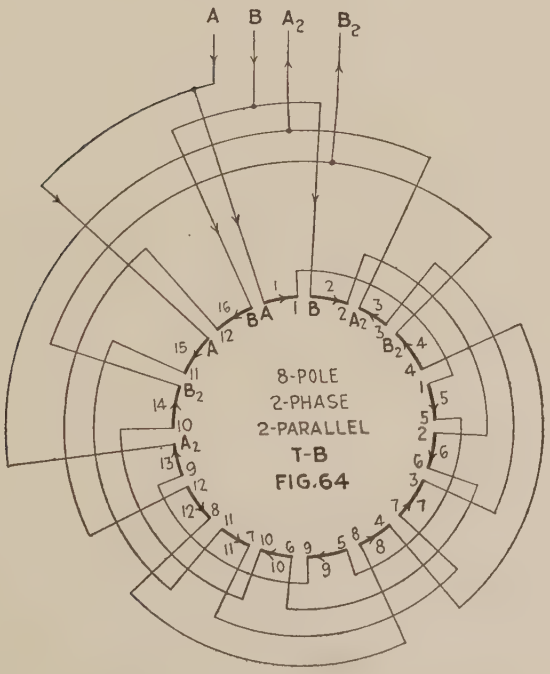
	Fig.																								
Series	63	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	7	4	8	5	9	6	10	7	11	8	12	9	13	10	14	11	13	12	14
2-parallel	64	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	A_2	"	B_2	"	A	"	B
4-parallel	65	"	"	"	"	"	"	"	"	"	A_2	"	B_2	"	A	"	B	A	"	B	"	A_2	"	B_2	"	"	A_2	"	"	"	"	"	B
8-parallel	66	"	A_2	"	B_2	"	A	"	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	"	B_2	B

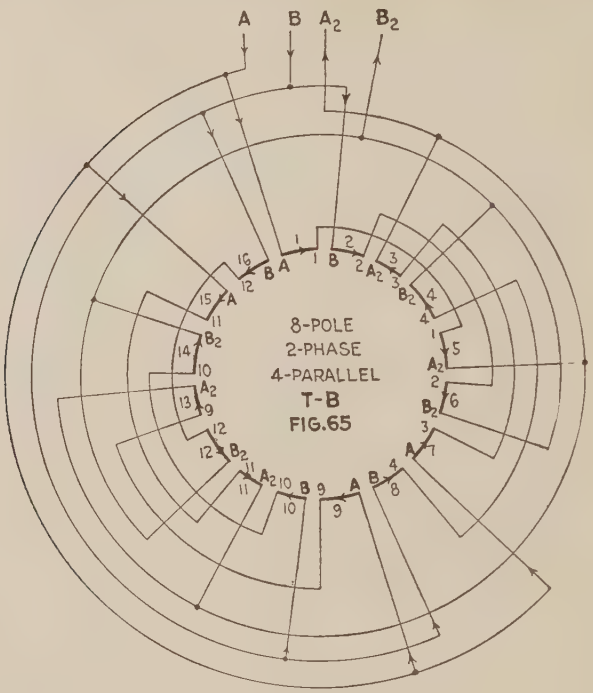

A
B
A2
B2
8-POLE
2-PHASE
SERIES
T-T
FIG.60

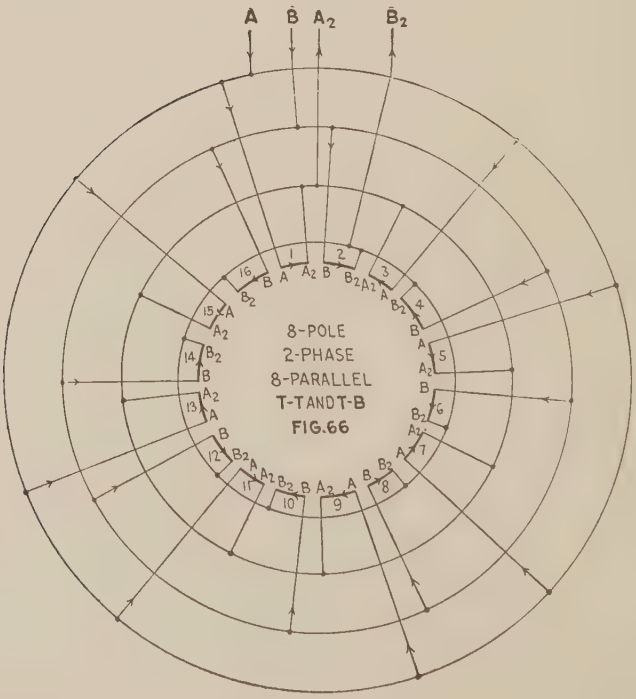

A B A2 B2
8-POLE
2-PHASE
2-PARALLEL
T-T
FIG. 61


A B A2 B2
8-POLE
2-PHASE
4-PARALLEL
T-T
FIG. 62


A B A2 B2
8-POLE
2-PHASE
SERIES
T-B
FIG.63


A B A2 B2
8-POLE
2-PHASE
2-PARALLEL
T-B
FIG.64


A
B
A2
B2
8-POLE
2-PHASE
4-PARALLEL
T-B
FIG.65


A
B
A2
B2
8-POLE
2-PHASE
8-PARALLEL
T-TANDT-B
FIG.66

CHAPTER XVI

EIGHT-POLE, THREE-PHASE, STAR DIAGRAMS AND CONNECTING TABLES

This chapter contains seven diagrams, one coil grouping chart and two connecting tables. The grouping chart is also used in conjunction with 8-pole, 3-phase, delta diagrams. The connections possible are series, 2-, 4- and 8-parallel star and from star to delta using any of the above connections. The majority of reconnections are from series to 2-parallel star or vice versa, series to 4-parallel or 2- to 4-parallel.

When changing from series star T-T (Fig. 67) to a 2-parallel star T-T (Fig. 68) Table 17 shows that jumpers 9, 11 and 13 are cut open and the tops of groups 8, 10 and 12 are connected to the star, the top of group 11 to the *B* line, the top of group 13 to the *A* line, and the top of group 15 to the *C* line.

When changing from 4-parallel star T-B (Fig. 72) to 2-parallel star T-B (Fig. 71) Table 18 shows that the star connection to the bottom of groups 5, 7 and 9 are cut open and also the tops of groups 11, 13 and 15 are cut from their respective line leads. Jumpers are then put on connecting the bottom of groups 5, 7 and 9 to the tops of groups 11, 13 and 15 or jumpers 6, 8 and 10 are put on.

A quick idea of the changes involved can be had from the tables for any reconnection desired even star to delta. Changing a star connection to delta simply means opening the star connections and connecting each free end of the proper line lead. This the tables show at a glance.

TABLES 17 AND 18.—CONNECTIONS FOR ENDS OF GROUPS OF 8-POLE, 3-PHASE WINDINGS

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is shown by (*).

TABLE 17.—8-POLE, 3-PHASE STAR, TOP-TO-TOP

See Figs. 67, 68, 69, 73

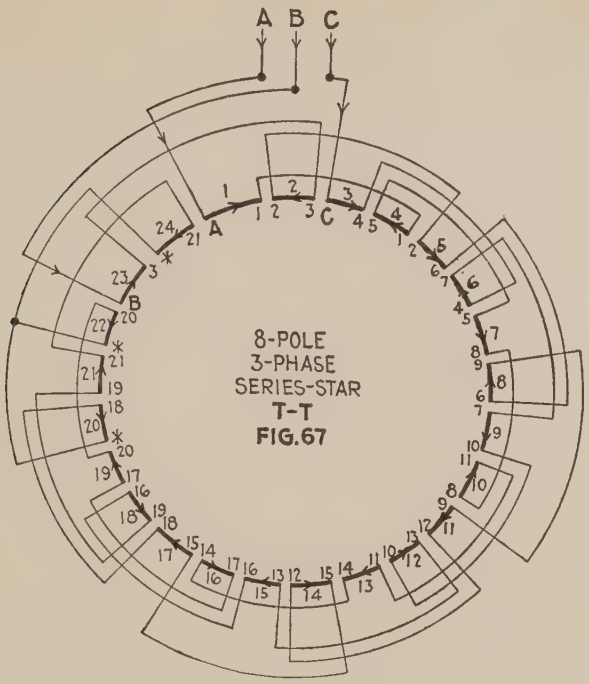
Pole number...		I			II			III			IV			V			VI			VII			VIII		
Group number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Fig.	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B
Series....	67	A	1	2	3	C	4	5	1	2	6	7	4	5	8	9	6	7	10	11	8	9	12	13	10
2-parallel	68	"	"	"	"	"	"	"	"	"	"	"	"	"	*	"	"	"	*	"	B	"	*	"	A	"	"
4-parallel	69	"	"	*	"	"	*	"	B	"	*	"	C	"	*	"	B	"	*	"	A	"	*	"	C	"	*
8-parallel	73	"	*	*	B	"	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*

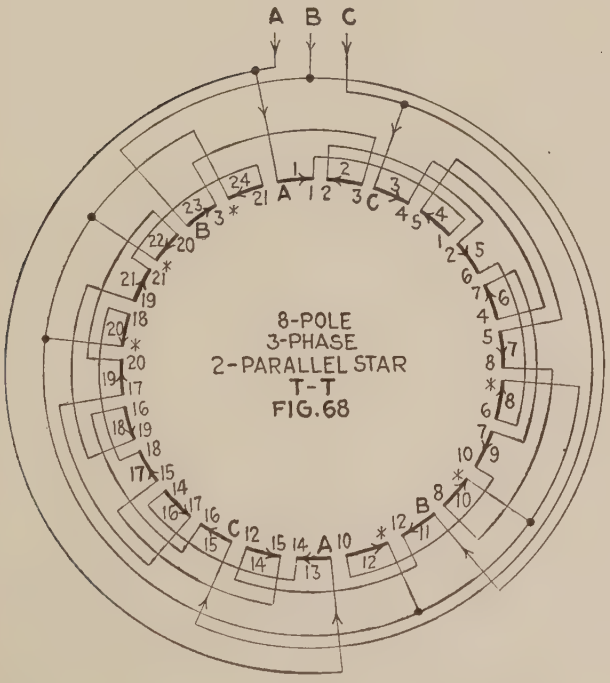
Pole number...		11	14	15	12	13	16	17	14	15	18	19	16	17	20	*	18	19	21	*	20	B	3	*	21
Group number		13	14	15	16	17	18	19	20	21	22	23	24												
	Fig.	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B												
Series....	67	A	"	"	"	C	"	"	"	"	"	"	"	A	"	"	"	C	"	"	"	"	"	"	"
2-parallel	68	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	69	"	*	"	C	"	*	"	B	"	*	"	A	"	*	"	C	"	*	"	B	"	*	"	C
8-parallel	73	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C

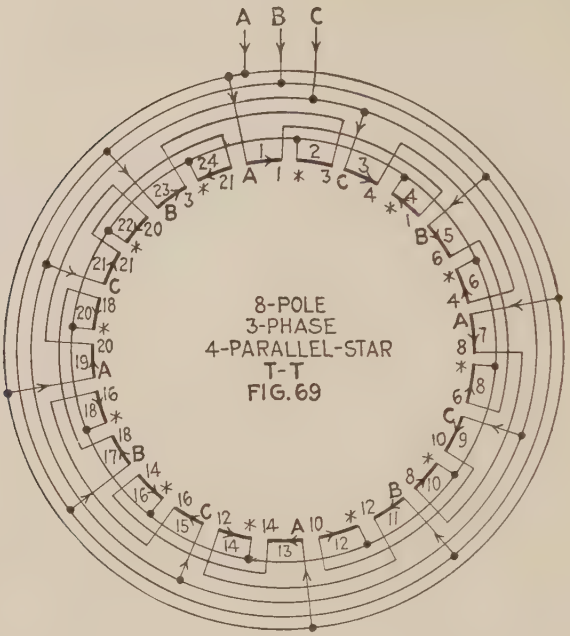
TABLE 18.—8-POLE, 3-PHASE STAR, TOP-TO-BOTTOM

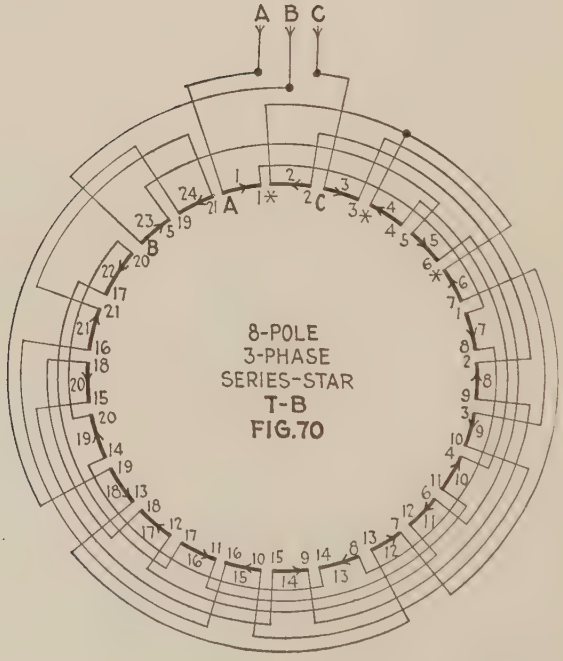
See Figs. 70, 71, 72, 73

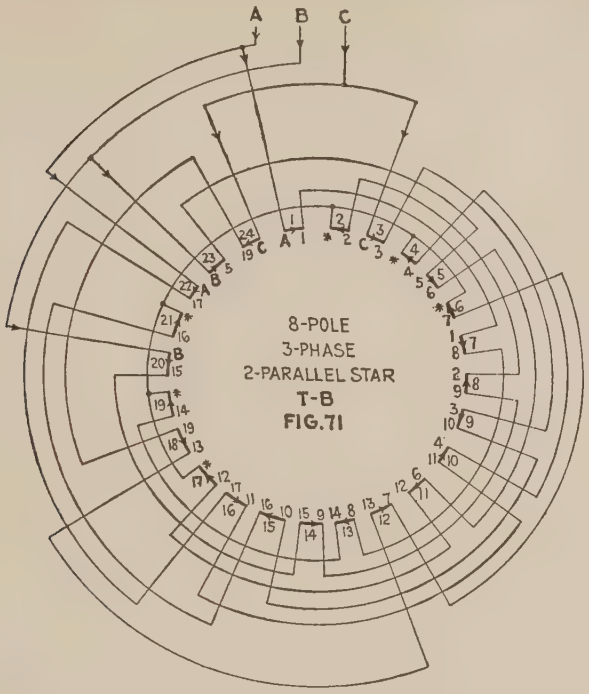
Series....	70	A	1	*	2	C	3	*	4	5	6	*	7	1	8	2	9	3	10	4	11	6	12	7	13	8	14	9	15	10	16	11	17	12	18	13	19	14	20	15	18	16	21	17	20	B	5	19	21
2-parallel	71	"	"	*	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	*	"	"	"	*	"	B	"	*	"	A	"	"	"	C
4-parallel	72	"	"	*	"	"	"	"	"	*	"	"	"	"	*	"	B	"	*	"	A	B	"	"	C	A	"	*	"	C	"	*	"	"	*	*	"	"	*	"	B	"	*	"	A	"	"	"	C
8-parallel	73	"	*	*	B	"	*	"	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	"	*	*	C

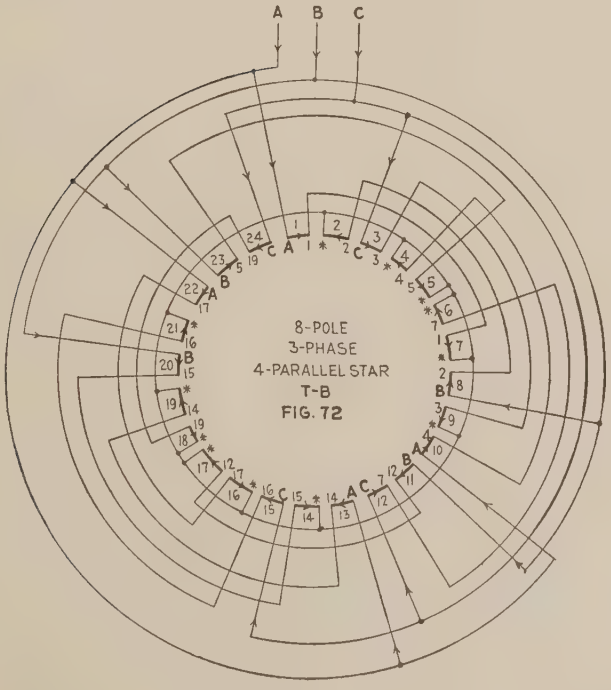

A B C
8-POLE
3-PHASE
SERIES-STAR
T-T
FIG.67

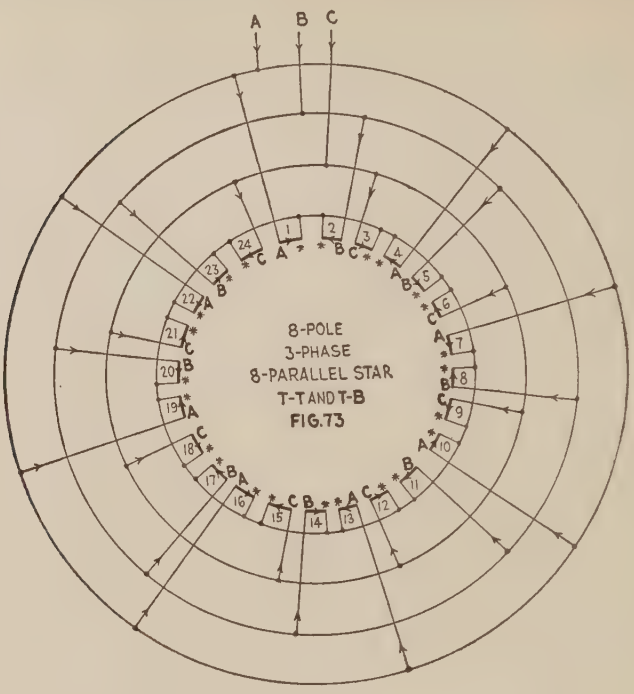

A B C
8-POLE
3-PHASE
2-PARALLEL STAR
T-T
FIG.68


A B C
8-POLE
3-PHASE
4-PARALLEL-STAR
T-T
FIG. 69


A B C
8-POLE
3-PHASE
SERIES-STAR
T-B
FIG. 70


A
B
C
8-POLE
3-PHASE
2-PARALLEL STAR
T-B
FIG. 71


A
B
C
8-POLE
3-PHASE
4-PARALLEL STAR
T-B
FIG. 72


A B C
8-POLE
3-PHASE
8-PARALLEL STAR
T-T AND T-B
FIG. 73

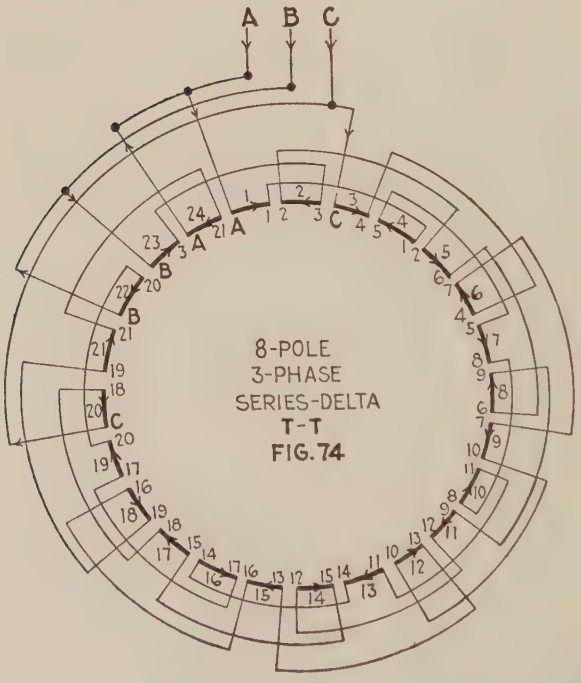

A B C
8-POLE
3-PHASE
SERIES-DELTA
T-T
FIG. 74

Chart H.—Unequal Coil Grouping for 8-pole, 3-phase Windings

8-pole, 3-phase, top-to-top, for star see Figs. 67, 68, 69, 73; for delta see Figs. 74, 75, 76, 80

Coils	Group numbers																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
36	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1
54	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2
60	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2
62	3	3–1	3	2	3	2	3	2	3	2	3	3–1	3	2	3	2	3	2	3	2	3	2	3	2
80	4	3	3	3	4	3	3	3	4	4–1	3	3	4	3	3	3	4	3	3	3	4	3	3	4–1
84	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3
86	4	4–1	4	3	4	3	4	3	4	3	4	4–1	4	3	4	3	4	3	4	3	4	3	4	3
90	3	4	4[k]	5	3	4	4[k]	4	3	4	4[k]	4	3	4	4[k]	4	3	4	4[k]	4	3	4	4[k]	4
104	5[k]	4	4	4	5[k]	4	4	4	5[k]	4	5–1	4	5[k]	4	4	4	5[k]	4	4	4	5[k]	4	4	5–1
108	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4
128	6[k]	5	5	5	6[k]	5	5	5	6[k]	5	6–1	5	6[k]	5	5	5	6[k]	5	5	5	6[k]	5	5	6–1
135	6	6–1	6	5	6	5	6	5	5[k]	6–1	6	5	6	5	6	5	6	6–1	6	5	6	5	6	5
150	7[k]	6	6	6	7[k]	6	6	6	7[k]	6	6	6	7[k]	6	6	6	7[k]	6	6	6	7[k]	6	6	6
156	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6
160	7	7–1	7	6	7	7–1	7	6	7	7–1	7	6	7	6	7	6	7	7–1	7	6	7	6	7	6
180	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7

8-pole, 3-phase, top-to-bottom. For star see Figs. 70, 71, 72, 73; for delta see Figs. 77, 78, 79, 80

Coils	Group numbers																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
36	2	1	2	1	2	1	1	2	1	2	1	2	2	1	2	1	2	1	1	2	1	2	1	2
54	3	2	2	2	2	2	2	3	2	2	2	3	2	2	3	2	3	2	2	2	2	3	2	2
60	3	2	3	2	3	2	2	3	2	3	2	3	3	2	3	2	3	2	2	3	2	3	2	3
62	3	3–1	3	2	3	2	2	3	2	3	2	3	3	3–1	3	2	3	2	2	3	2	3	2	3
80	4	3	3	3	4–1	3	3	4	3	3	3	4	3	3	4	3	4	3	3	4–1	3	4	3	3
84	4	3	4	3	4	3	3	4	3	4	3	4	4	3	4	3	4	3	3	4	3	4	3	4
86	4	4–1	4	3	4	3	3	4	3	4	3	4	4	4–1	4	3	4	3	3	4	3	4	3	4
90	3	4	4	4	4[k]	3	4	3	3	4[k]	4	4	4[k]	4[k]	4	4	3	4[k]	4	4	4[k]	3	4	4
104	5[k]	4	4	4	5–1	4	4	5[k]	4	4	4	5[k]	4	4	5[k]	4	5[k]	4	4	5	1	4	5[k]	4	4
108	5	4	5	4	5	4	4	5	4	5	4	5	5	4	5	4	5	4	4	5	4	5	4	5
128	6[k]	5	5	5	6–1	5	5	6[k]	5	5	5	6[k]	5	5	6[k]	5	6[k]	5	5	6–1	5	6[k]	5	5
135	6	5	6	6–1	6	5	5	6	5	6	6–1	6	6	5	6	5	6	6–1	5	6	5	6	5	6
150	7[k]	6	6	6	6	6	6	7[k]	6	6	6	7[k]	6	6	7[k]	6	7[k]	6	6	6	6	7[k]	6	6
156	7	6	7	6	7	6	6	7	6	7	6	7	7	6	7	6	7	6	6	7	6	7	6	7
160	7	7–1	7	6	7	7–1	6	7	6	7	6	7	7	7–1	7	6	7	7–1	6	7	6	7	6	7
180	8	7	8	7	8	7	7	8	7	8	7	8	8	7	8	7	8	7	7	8	7	8	7	8

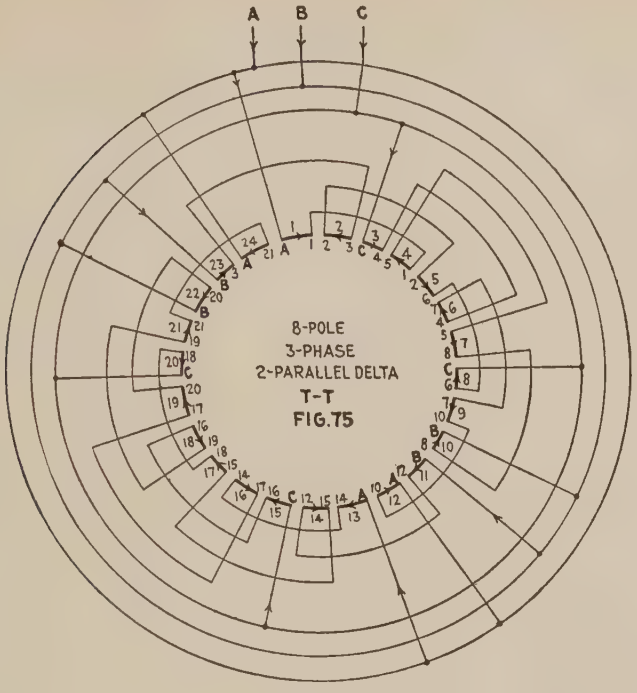
[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding (see pages 8–9).

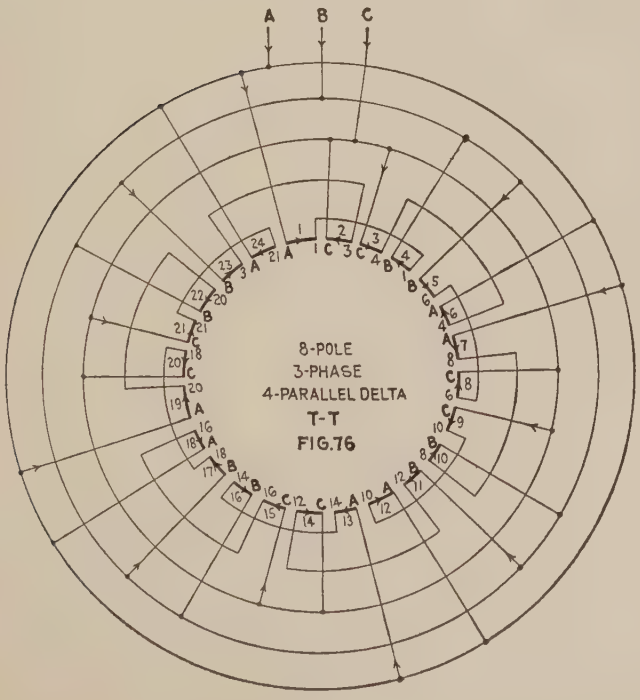
CHAPTER XVII

EIGHT-POLE, THREE-PHASE, DELTA DIAGRAMS AND CONNECTING TABLES

For odd coil groupings use Chart H for 8-pole, 3-phase, star in Chapter 16. With the delta diagrams, the same reconnections are possible as explained in Chapter 16. A change from a delta to a star connection can be made by the selection of the proper diagrams and tables and noting the points where changes occur.

When the change seems confusing, study the tables for top lead changes only, then for bottom, etc., and make the changes as the winding diagrams are checked.


A
B
C
8-POLE
3-PHASE
2-PARALLEL DELTA
T-T
FIG.75


A
B
C
8-POLE
3-PHASE
4-PARALLEL DELTA
T-T
FIG.76

Tables 19 and 20.—Connections for Ends of Groups for 8-pole, 3-phase delta T-T and T-B Windings

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is shown by (*)

Table 19.—8-pole, 3-phase, Delta, Top-to-top.

See Figs. 74, 75, 76 and 80

Pole number.....		I			II			III			IV			V			VI			VII			VIII		
Group number.....		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Fig.	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B	T-B
Series.....	74	A	1	2	3	C	4	5	1	2	6	7	4	5	8	9	6	7	10	11	8	9	12	13	10
2-parallel...	75	"	"	"	"	"	"	"	"	"	"	"	"	"	"	C	"	"	"	B	"	B	"	A	"
4-parallel...	76	"	"	C	"	"	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"
8-parallel...	80	"	B	C	B	"	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C

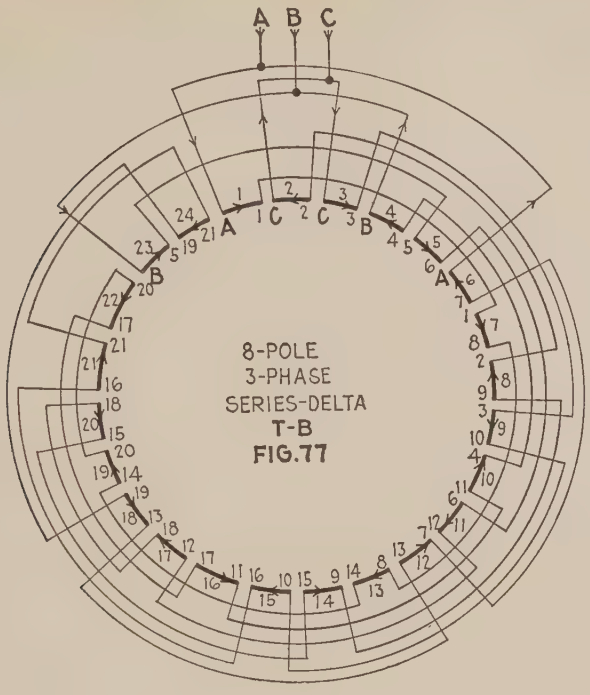
		11	14	15	12	13	16	17	14	15	18	19	16	17	20	C	18	19	21	B	20	B	3	A	21
		A	"	"	A	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
		A	"	C	"	C	"	B	"	C	"	B	"	A	"	A	"	C	"	B	"	B	"	C	"
		A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	A	B	A	B	C	A	C	A	B	"	B	C	A	"	A	"	C	"	C

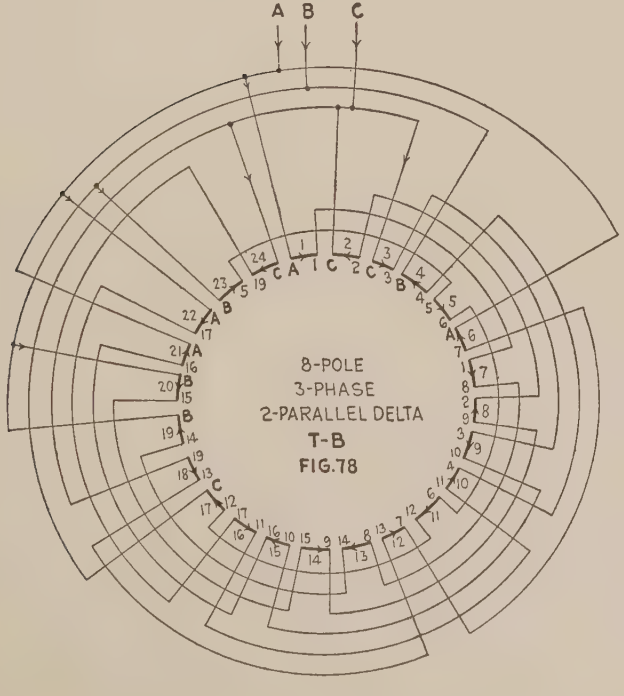
Table 20.—8-pole, 3-phase, Delta, Top-to-bottom.

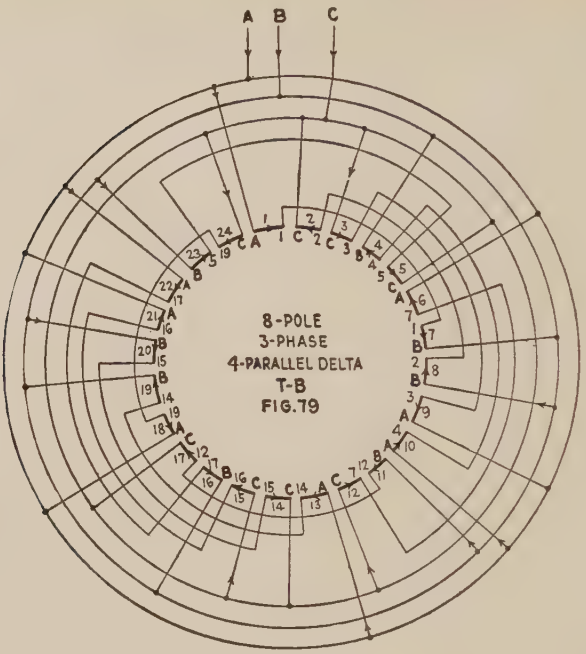
See Figs. 77, 78, 79 and 80

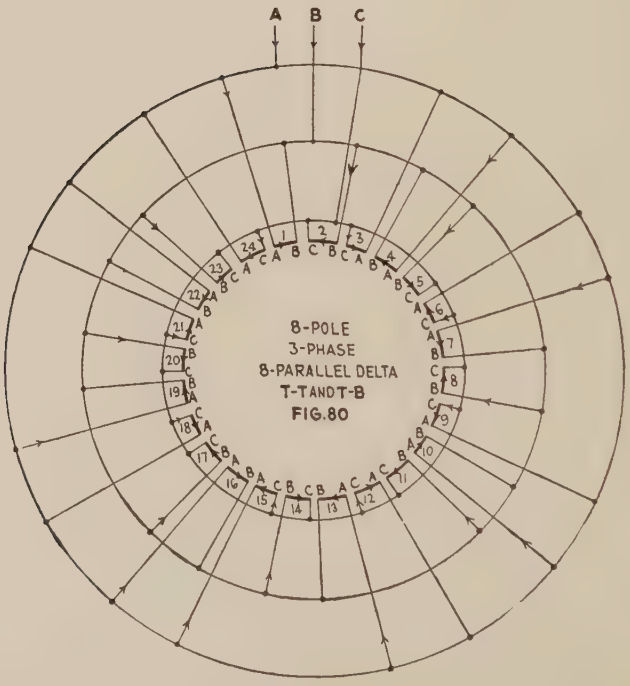
Series.....	77	A	1	C	2	C	3	B	4	5	6	A	7	1	8	2	9	3	10	4	11	6	12	7	13
2-parallel.....	78	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel.....	79	"	"	"	"	"	"	"	"	"	C	"	"	B	"	B	"	A	"	A	B	"	"	C	A
8-parallel.....	80	"	B	"	B	"	A	"	A	B	C	"	C	A	B	C	B	C	A	B	A	B	C	A	C

		8	14	9	15	10	16	11	17	12	18	13	19	14	20	15	18	16	21	17	20	B	5	19	21
		"	"	"	"	"	"	"	"	"	C	"	"	"	B	"	B	"	A	"	A	"	"	"	C
		A	"	C	"	C	"	B	"	"	C	A	"	"	B	"	B	"	A	"	A	"	"	"	C
		A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	"	C	A	C


A B C
8-POLE
3-PHASE
SERIES-DELTA
T-B
FIG.77


A B C
8-POLE
3-PHASE
2-PARALLEL DELTA
T-B
FIG.78


A B C
8-POLE
3-PHASE
4-PARALLEL DELTA
T-B
FIG.79


A B C
8-POLE
3-PHASE
8-PARALLEL DELTA
T-TANDT-B
FIG.80

CHAPTER XVIII

TEN-POLE, TWO-PHASE DIAGRAMS AND CONNECTING TABLES

With 10-pole windings the possible connections are series, 2- 5- and 10-parallel. By far the majority of reconnections are from series to 2-parallel or vice versa; or changing from a *T-B* to a *T-T* connection to permit a parallel connection with a certain coil grouping arrangement.

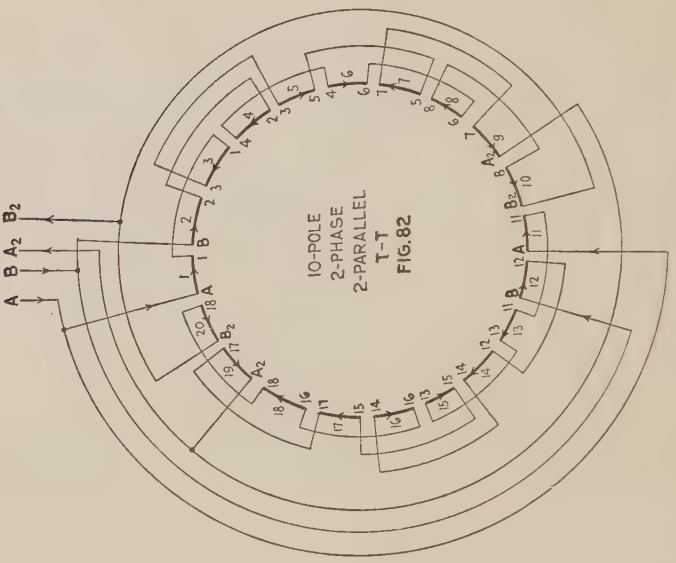
A change from a series to a 5-parallel connection would enable a 1100-volt motor to be used on 220 volts or series to 10-parallel on 1100 to 110 volts, etc.

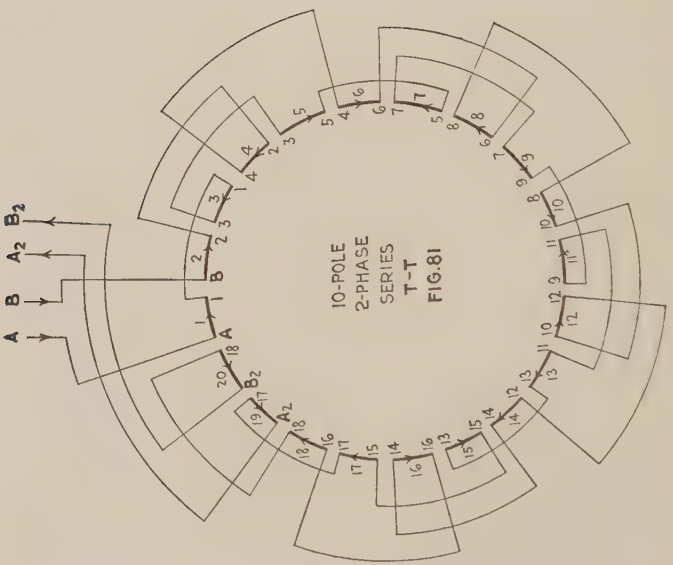
CHART K.—UNEQUAL COIL GROUPING FOR 10-POLE, 2-PHASE WINDINGS

10 pole, 2-phase, top-to-top connections. See Figs. 81, 82, 83 and 87

No. Coils	Group Numbers																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
48	3	2	2	3	3	2	2	3	2	2	3	2	2	3	3	2	2	3	2	2
54	2	3	3	2	3	3	2	3[k]	3	3	2	3	3	2	3[k]	3	2	3	3	3
62	4–1	3	3	3	3	3	3	3	3	3	3	4–1	3	3	3	3	3	3	3	3
72	3	4	4	3	3	4	4	3	4	4	3	4[k]	4	3	3	4	4	3	4[k]	4
84	5[k]	4	4	4	4	5[k]	4	4	4	4	5[k]	4	4	4	4	5[k]	4	4	4	4
86	5[k]	4	4	5–1	4	5[k]	4	4	4	4	5[k]	4	5–1	4	4	5[k]	4	4	4	4
90	5–1	4	4	4	5	5	4	4	5	5	4	5–1	4	4	5	5	4	4	5	5
96	4	5	5	5[k]	5[k]	4	5	5	5	5	4	5[k]	5[k]	5	5	4	5[k]	5	5	5[k]
104	6[k]	5	5	5	5	6[k]	5	5	5	5	6[k]	5	5	5	5	6[k]	5	5	5	5
108	6	5	5	6	6	5	5	6	5	5	6	5	5	6	6	5	5	6	5	5
128	7	6	6	7	7	6	6	7	6	6	7	6	6	7	7	6	6	7	6	6
135	7–1	7	7	6	6	7	7	6	7	7[k]	7–1	7	7	7–1	6	7	7	6	7[k]	7
144	8[k]	7	7	7	7	8[k]	7	7	7	7	8[k]	7	7	7	7	8[k]	7	7	7	7
150	8–1	7	7	7	8	8	7	7	8	8	7	7	7	7	8	8	7	8–1	8	8
156	7	8	8	8	8	7	8	8	8	8	7	8	8	8	8	7	8	8	8	8
168	9	8	8	9	9	8	8	9	8	8	9	8	8	9	9	8	8	9	8	8
216	10	11	11	11	11	10	11	11	11	11	10	11	11	11	11	10	11	11	11	11

[k]A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding (see page 8–9).


A B A2 B2
10-POLE
2-PHASE
2-PARALLEL
T-T
FIG. 82


A B A2 B2
10-POLE
2-PHASE
SERIES
T-T
FIG. 81

TABLES 21 AND 22.—CONNECTIONS FOR ENDS OF GROUPS OF 10-POLE, 2-PHASE, *T-T* AND *T-B* WINDINGS

Connect together group ends having same numbers or letters. Line leads are indicated by letters. A star connection is shown by (*)

TABLE 21.—10-POLE, 2-PHASE, TOP-TO-TOP. SEE FIGS. 81, 82, 83 AND 87

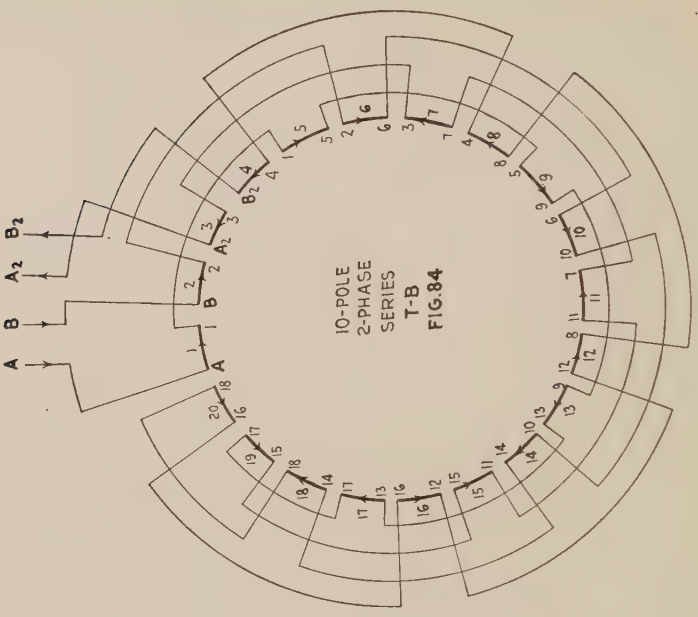
Pole No.		I				II				III				IV				V			
Group No.	Fig.	1		2		3		4		5		6		7		8		9		10	
Series	81	A	1	B	2	3	1	4	2	3	5	4	6	7	5	8	6	7	9	8	10
2 Parallel	82	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	A_2	"	B_2
5 Parallel	83	"	"	"	"	A_2	"	B_2	"	A	"	B	"	A_2	"	B_2	"	A	9	B	10
10 Parallel	87	"	A_2	"	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2

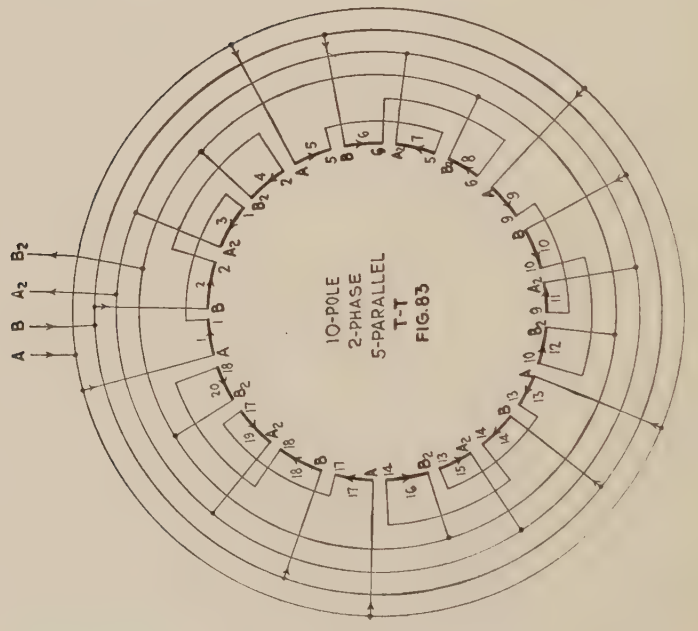
Pole No.		VI				VII				VIII				IX				X			
Group No.		11		12		13		14		15		16		17		18		19		20	
Series		11	9	12	10	11	13	12	14	15	13	16	14	15	17	16	18	A_2	17	B_2	18
2 Parallel		"	A	"	B	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
5 Parallel		A_2	9	B_2	10	A	"	B	"	A_2	"	B_2	"	A	"	B	"	"	"	"	"
10 Parallel		A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

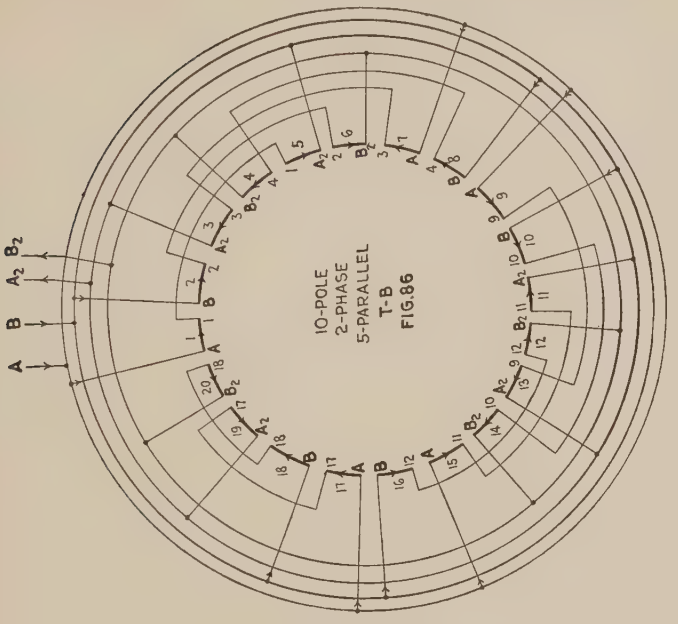
TABLE 22.—10-POLE, 2-PHASE, TOP-TO-BOTTOM. SEE FIGS. 84, 85, 86 AND 87

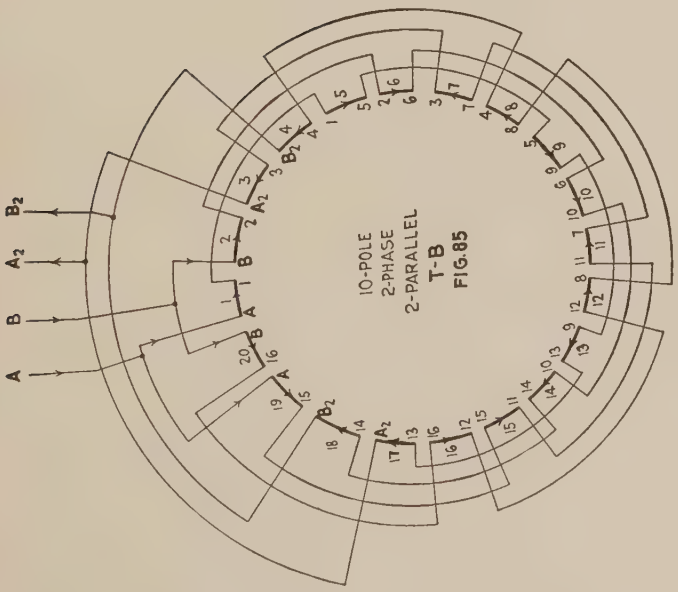
Pole No.		I				II				III				IV				V			
Group No.	Fig.	1		2		3		4		5		5		7		8		9		10	
Series	84	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	7	4	8	5	9	6	10
2 Parallel	85	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
5 Parallel	86	"	"	"	"	"	"	"	"	"	A_2	"	B_2	"	A	"	B	A	"	B	"
10 Parallel	87	"	A_2	"	B_2	"	A	"	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2

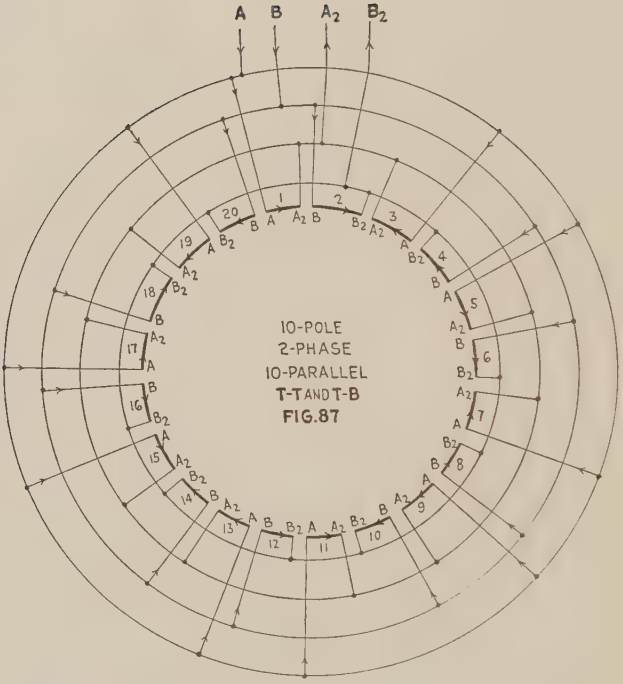
Pole No.		VI				VII				VIII				IX				X			
Group No.		11		12		13		14		15		16		17		18		19		20	
Series		7	11	8	12	9	13	10	14	11	15	12	16	13	17	14	18	15	17	16	18
2 Parallel		"	"	"	"	"	"	"	"	"	"	"	"	"	A_2	"	B_2	"	A	"	B
5 Parallel		A_2	"	B_2	"	"	A_2	"	B_2	"	A	"	B	A	17	B	18	A_2	17	B_2	18
10 Parallel		A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B


A B A2 B2
10-POLE
2-PHASE
SERIES
T-B
FIG.84


A B A2 B2
10-POLE
2-PHASE
5-PARALLEL
T-T
FIG.83


A
B
A2
B2
10-POLE
2-PHASE
5-PARALLEL
T-B
FIG.86


A
B
A2
B2
10-POLE
2-PHASE
2-PARALLEL
T-B
FIG.85


A
B
A2
B2
10-POLE
2-PHASE
10-PARALLEL
T-T AND T-B
FIG. 87

CHAPTER XIX

TEN-POLE, THREE-PHASE, STAR DIAGRAMS AND CONNECTING TABLES

This chapter covers all the 10-pole star connections. The tables and diagrams enable any possible reconnection to be made. The methods of using the tables has been explained in the previous chapters. This consists of selecting the two diagrams that give the present and desired connection with the respective tables. Then note the changes required.

TABLES 23 AND 24.—CONNECTIONS FOR ENDS OF GROUPS FOR 10-POLE, 3-PHASE, STAR *T-T* AND *T-B* WINDINGS

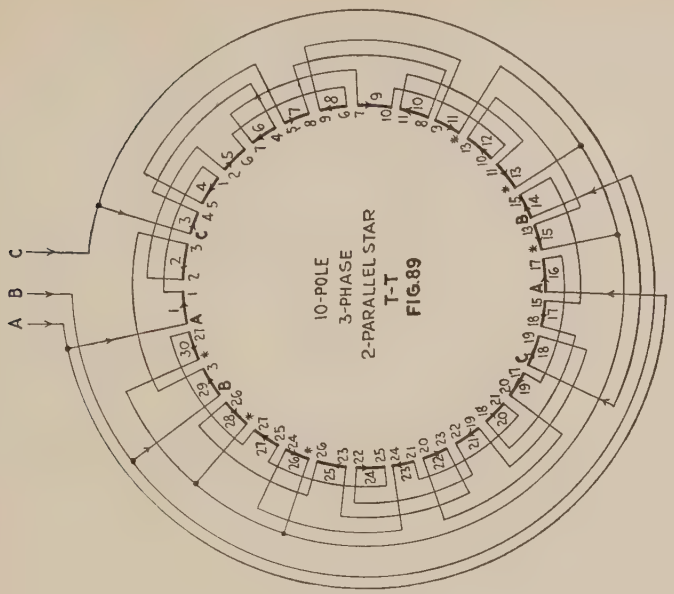
Connect together group ends having same numbers or letters. Line leads are indicated by letters. A star connection is shown by (*)

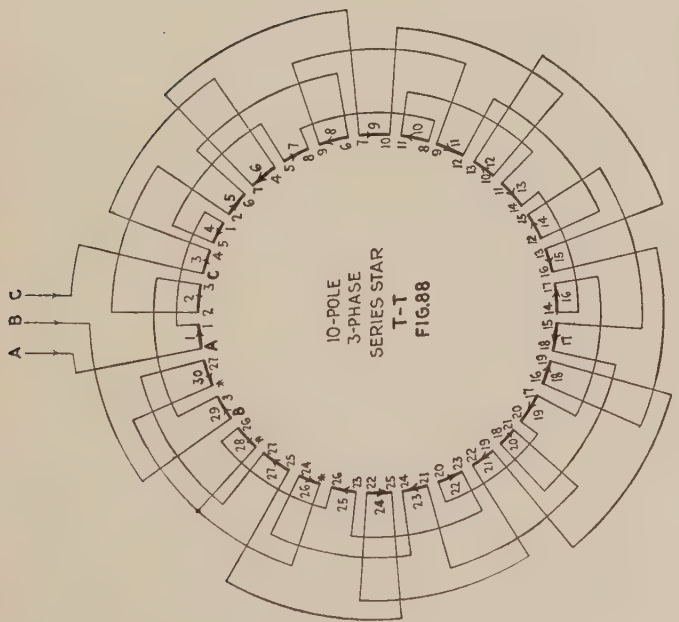
TABLE 23.—10-POLE, 3-PHASE STAR, TOP-TO-TOP. SEE FIGS. 88, 89, 90 AND 94

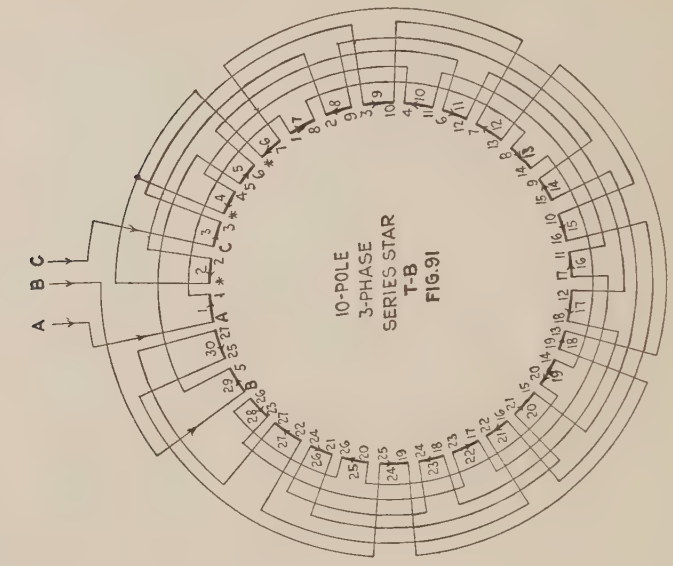
Pole No.		I			II			III			IV			V		
Group No.	Fig.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Series	88	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 19
2 Parallel	89	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	* "	" "	* "	B "	" *
5 Parallel	90	" "	* "	" "	* "	" B	" *	A "	* "	C "	* "	B 12	* "	A 14	* 12	C 16
10 Parallel	94	" *	* B	" *	* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	* B	C *

Pole No.		VI			VII			VIII			IX			X		
Group No.		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Series		17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	* 24	25 27	* 26	B 3	* 27
2 Parallel		" A	" "	" C	A "	* "	" B	C "	* "	" C	A "	" "	C "	" "	" "	" "
5 Parallel		* 14	B "	* 16	A "	* "	C "	* "	B "	* "	A "	" "	C "	" "	" "	" "
10 Parallel		* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	" B	C *	" A	" *	" C

For Table 24, see page 131.


10-POLE
3-PHASE
2-PARALLEL STAR
T-T
FIG.89
A B C


10-POLE
3-PHASE
SERIES STAR
T-T
FIG.88
A B C


A B C
10-POLE
3-PHASE
SERIES STAR
T-B
FIG.91

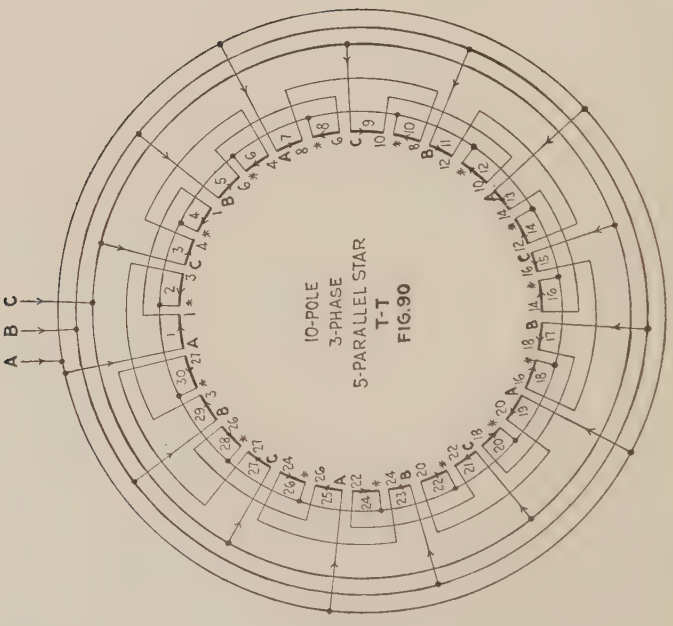
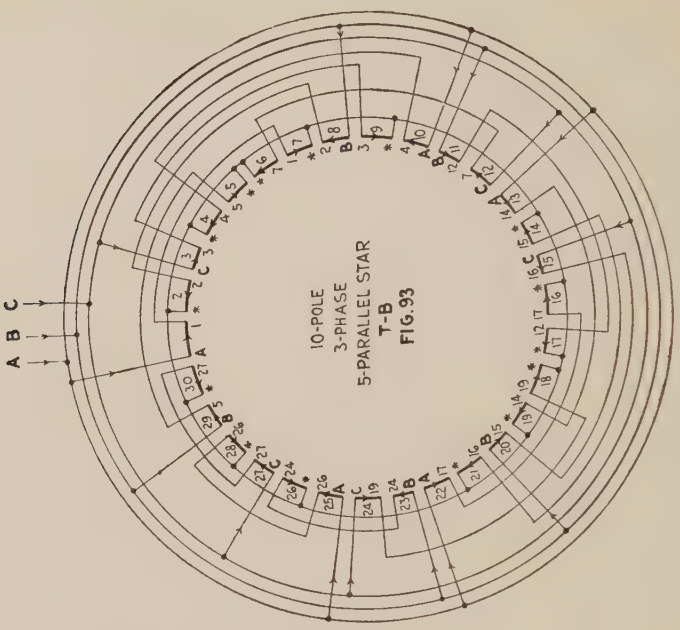
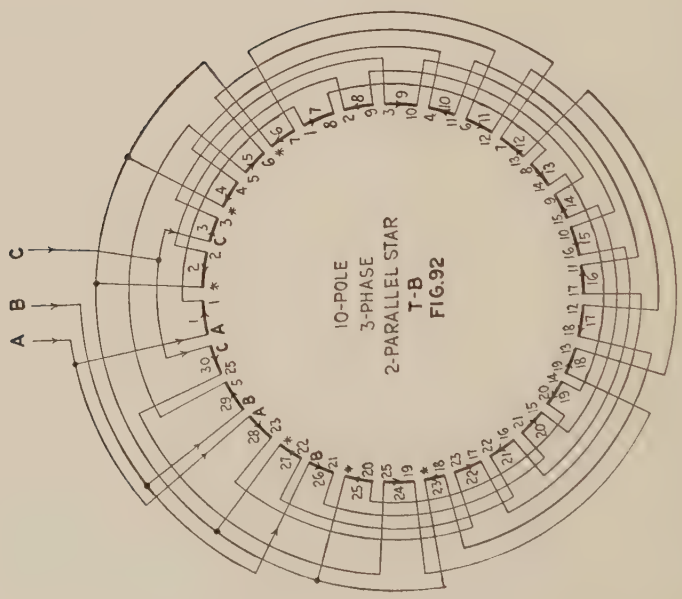

A B C
10-POLE
3-PHASE
5-PARALLEL STAR
T-T
FIG.90

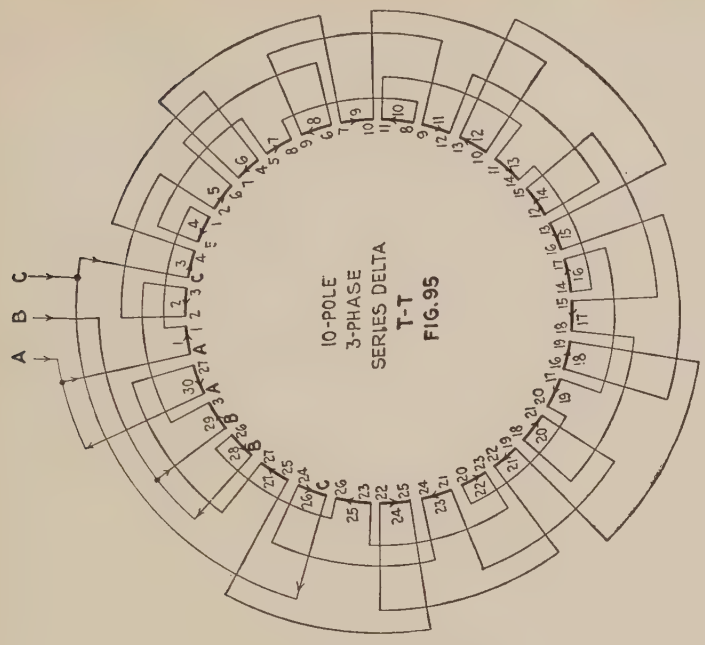
TABLE 24.—10-POLE, 3-PHASE STAR, TOP-TO-BOTTOM. SEE FIGS. 91, 92, 93 AND 94

Pole No.		I			II			III			IV			V		
Group No.	Fig.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Series	91	A 1	* 2	C 3	* 4	5 6	* 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16
2 Parallel	92	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
5 Series	93	" "	" "	" "	" "	" *	" "	" *	" *	" *	" A	B "	" C	A "	" *	" C	"
10 Parallel	94	" *	" B	" *	" A	B *	" C	A *	* B	C *	* A	B *	* C	A *	* B	C *

Pole No.		VI			VII			VIII			IX			X		
Group No.		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Series		11 17	12 18	13 19	14 20	15 21	16 22	17 23	18 24	19 25	20 26	21 24	22 27	23 26	B 5	25 27
2 Parallel		" "	" "	" "	" "	" "	" "	" "	" *	" "	" *	" B	" *	" A	" "	" C
5 Series		* "	" *	* "	" *	" B	" *	" A	B 24	" C	A 26	* 24	C 27	* 26	" "	* 27
10 Parallel		* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	" *	* C


A B C
10-POLE
3-PHASE
5-PARALLEL STAR
T-B
FIG. 93


A B C
10-POLE
3-PHASE
2-PARALLEL STAR
T-B
FIG. 92


10-POLE
3-PHASE
SERIES DELTA
T-T
FIG.95
A B C

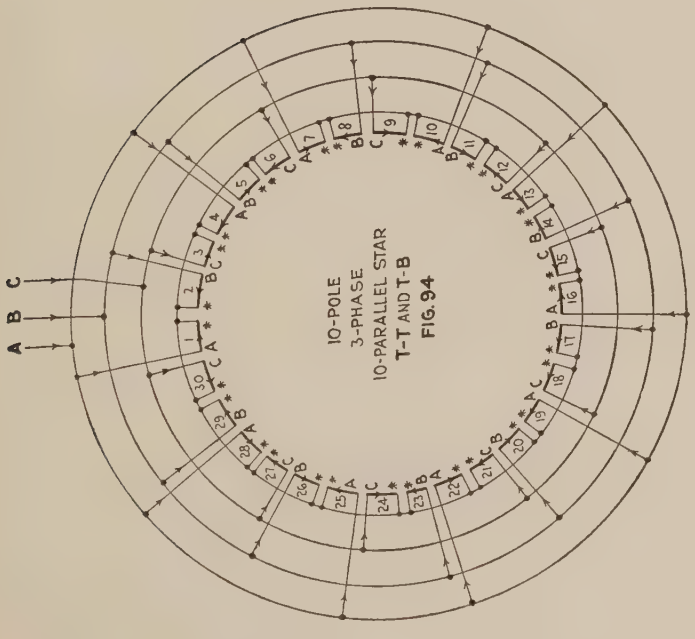

10-POLE
3-PHASE
10-PARALLEL STAR
T-T AND T-B
FIG.94
A B C

Chart L.—Unequal Coil Groupings for 10-pole, 3-phase, Star and Delta Windings

10-pole, 3-phase, top-to-top and top-to-bottom connections. See Figs. 88 to 101

No. Coils	Group Numbers																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	17	18	19	20	21	22	23	24	25	26	27	28	29	30
48	2	1	2	1	2	2	2	1	1	2	2	1	1	2	2	2	1	2	1	2	2	2	1	1	2	2	1	1	2	2
54	1	2	2	2	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	1	2	2	2	1	2	2	2
62	3–1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3–1	2	2	2	2	2	2	2	2	2	2	2	2
72	2	3	2	3	2	2	2	3	3	2	2	3	3	2	2	2	3	2	3	2	2	2	3	3	2	2	3	3	2	2
80	3	2	3	2	3	3	3	3–1	2	3	3	2	2	3	3	3	2	3	2	3	3	3	2	3–1	3	3	2	2	3	3
84	2	3	3	3	3	2	3	3	3	3	2	3	3	3	3	2	3	3	3	3	2	3	3	3	3	2	3	3	3	3
86	3–1	3	3	3	3	2	3	3	3	3	2	3	3	3	3	2	3	3	3	3	3–1	3	3	3	3	2	3	3	3	3
96	4	3	3	3	3	4	3	3	3	3	4	3	3	3	3	4	3	3	3	3	4	3	3	3	3	4	3	3	3	3
104	4–1	4	3	4	3	3	3	4	4	3	3	4	4	3	3	3	4	4–1	4	3	3	3	4	4	3	3	4	4	3	3
108	4	3	4	3	4	4	4	3	3	4	4	3	3	4	4	4	3	4	3	4	4	4	3	3	4	4	3	3	4	4
128	5	4	4	4	5-1	4	4	5	4	4	4	5	4	4	4	5	4	4	4	5	5 1	4	5	4	4	4	5	4	4	4
†135	5	4	5	4	5	4	5	4	5	4	5	4	5[k]	4	5[k]	4	5	4	5	4	5	4	5	4	5	4	5	4	5[k]	4
144	4	5	5	5	5	5	5	4	5	5	5	4	5	5	5	4	5	5	5	5	5	5	4	5	5	5	4	5	5	5
156	6	5	5	5	5	5	5	6	5	5	5	6	5	5	5	6	5	5	5	5	5	5	6	5	5	5	6	5	5	5
160	6	5	5	6 1	5	5	5	6	5	5	6	5	5	6 1	5	6	5	5	5	5	6 1	5	6	5	5	5	6	5	5	6–1
168	6	5	6[k]	5	5	6	5	6	6	6	6	5	6	6[k]	5	6[k]	5	6	5	6	6	6	6	5	6	5	5[k]	5	6	6
216	8[k]	7	7	7	7	7	7	8[k]	7	7	7	8[k]	7	7	7	8[k]	7	7	7	7	7	7	8[k]	7	7	7	8	7	7	7

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding (see page 8–9).

† Not good for top-to-top bottom connection.

CHAPTER XX

TEN-POLE, THREE-PHASE, DELTA DIAGRAMS AND CONNECTING TABLES

In this chapter are grouped all the 10-pole delta diagrams. For odd coil groupings use chart *L* in Chapter 19. The tables and diagrams with the data in previous chapters will enable any connection within the range of the diagrams to be made with a little study. Also changes from delta to star connections can be made as mentioned in other chapters.

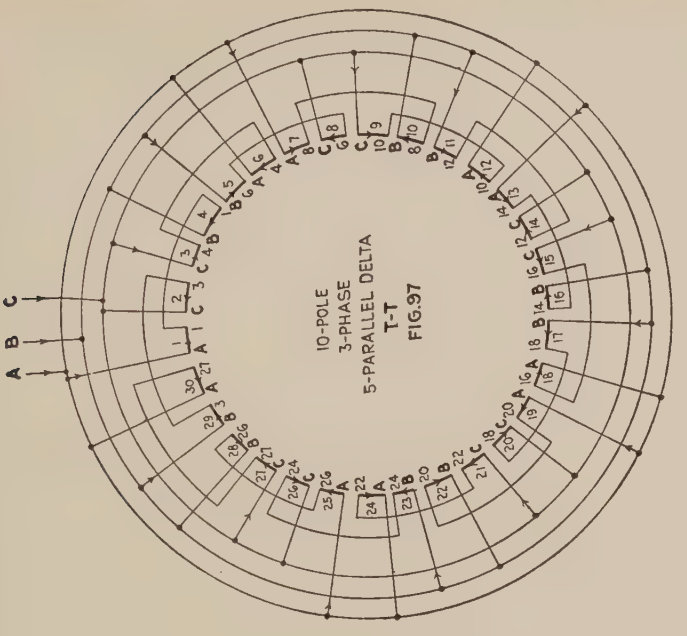
TABLES 25 AND 26.—CONNECTIONS FOR ENDS OF GROUPS FOR 10-POLE, 3-PHASE, DELTA, *T-T* AND *T-B* WINDINGS
Connect together group ends having same numbers or letters. Line leads are indicated by letters. A star connection is shown by (*)

TABLE 25.—10-POLE, 3-PHASE DELTA, TOP-TO-TOP. SEE FIGS. 95, 96, 97 AND 101

Pole No.		I			II			III			IV			V		
Group No.	Fig.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Series	95	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16
2 Parallel	96	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" C	" "	" B	" B	" A
5 Parallel	97	" "	C "	" "	B "	A "	C "	A "	C "	C "	B "	B 12	A "	A 14	C 12	C 16
10 Parallel	101	" B	C B	" A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A

Pole No.		VI			VII			VIII			IX			X		
Group No.		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Series	17	14 15	18 19	16 17	20 21	18 19	22 23	20 21	24 25	22 23	26 C	24 25	27 B	26 B	3 A	27
2 Parallel		" A	" "	C "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
5 Parallel	B	14 B	" A	16 A	A "	C "	C "	B "	B "	A "	A "	C "	" "	" "	" "	" "
10 Parallel	B	A B	C A	C A	B C	B C	A B	A B	C A	C A	A B	" B	C A	" A	" C	" C

For Table 26, see page 138.


A B C
10-POLE
3-PHASE
5-PARALLEL DELTA
T-T
FIG.97

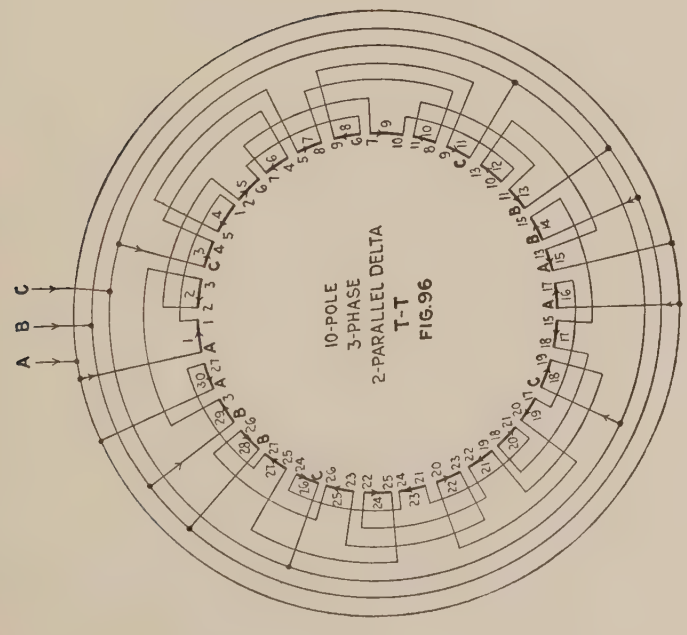
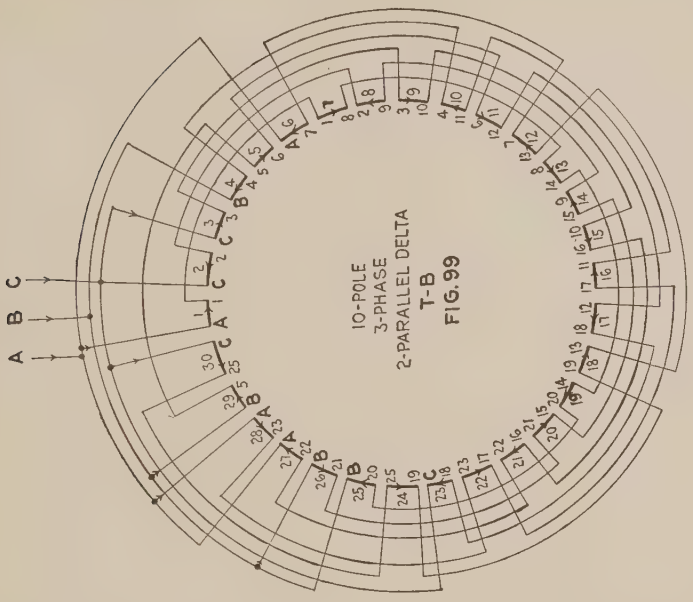
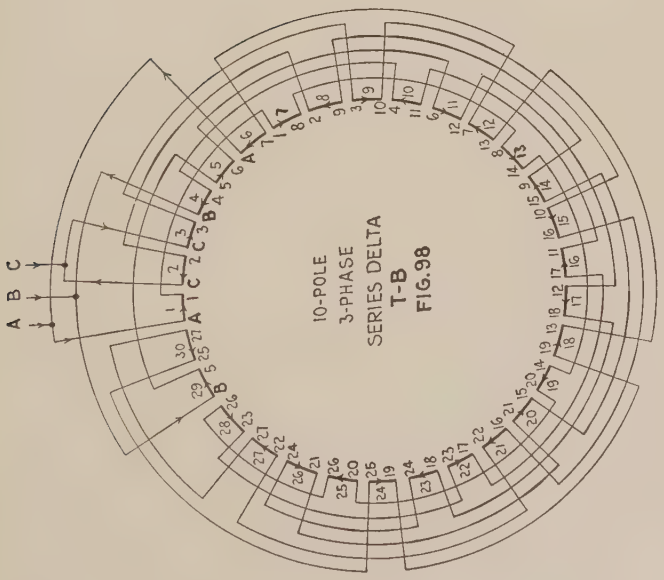

A B C
10-POLE
3-PHASE
2-PARALLEL DELTA
T-T
FIG.96

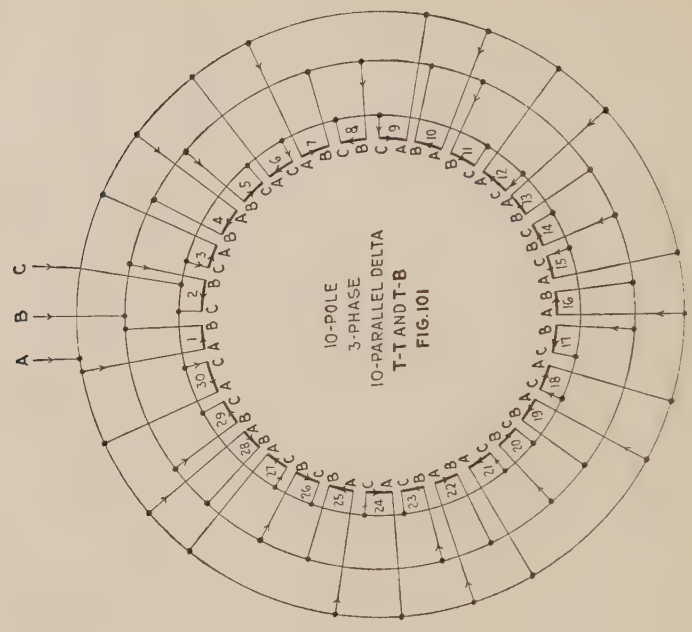
TABLE 26.—10-POLE, 3-PHASE DELTA, TOP-TO-BOTTOM. SEE FIGS. 98, 99, 100 AND 101

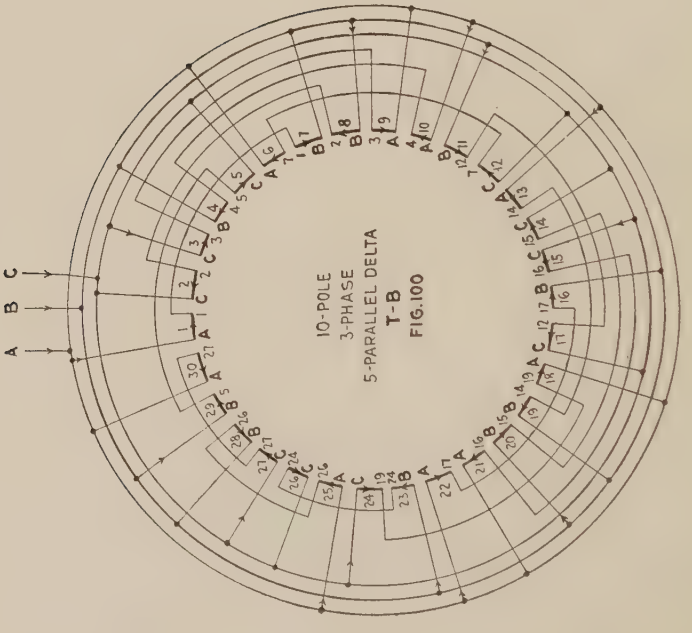
Pole no.		I			II			III			IV			V		
Group no.	Fig.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Series	98	A 1	C 2	C 3	B 4	5 6	A 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16
2 Parallel	99	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
5 Parallel	100	" "	" "	" "	" "	" C	" "	" B	" B	" A	A B	B "	" C	A "	C "	C "
10 Parallel	101	" B	" B	" A	" A	B C	" C	A B	C B	C A	B A	B C	A C	A B	C B	C A

Pole no.		VI			VII			VIII			IX			X		
Group no.		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Series	11	17	12 18	13 19	14 20	15 21	16 22	17 23	18 24	19 25	20 26	21 24	22 27	23 26	B 5	25 27
2 Parallel	"	"	" "	" "	" "	" "	" "	" "	" C	" "	" B	" B	" A	" A	" "	" C
5 Series	B	"	" C	A "	" B	" B	" A	" A	B 24	" C	A 26	C 24	C 27	B 26	" "	A 27
10 Parallel	B	A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	" C	A C


A B C
10-POLE
3-PHASE
2-PARALLEL DELTA
T-B
FIG.99


A B C
10-POLE
3-PHASE
SERIES DELTA
T-B
FIG.98


A B C
10-POLE
3-PHASE
10-PARALLEL DELTA
T-T AND T-B
FIG. 101


A B C
10-POLE
3-PHASE
5-PARALLEL DELTA
T-B
FIG. 100

CHAPTER XXI

TWELVE-POLE, TWO-PHASE DIAGRAMS AND CONNECTING TABLES

In any 12-pole motor there is the choice of six connections; namely, series, 2-, 3-, 4-, 6- and 12-parallel. By proper use of the diagrams and tables quite a number of connections can be made. The series, 2-, and 4-parallel winding can be used for 440, 220 and 110 volts and these form the majority of reconnection cases.

To change from 2-parallel *T-T* (Fig. 103) to 4-parallel (Fig. 105) Table 27 shows that the bottom of groups 5, 6, 7 and 8 are changed or jumper 5 and 6 are cut open and the ends connected to the lines as indicated in the table. Groups 17, 18, 19 and 20 are also changed in the same manner.

To change from series to 4-parallel, the table will also show where a change in jumpers is necessary.

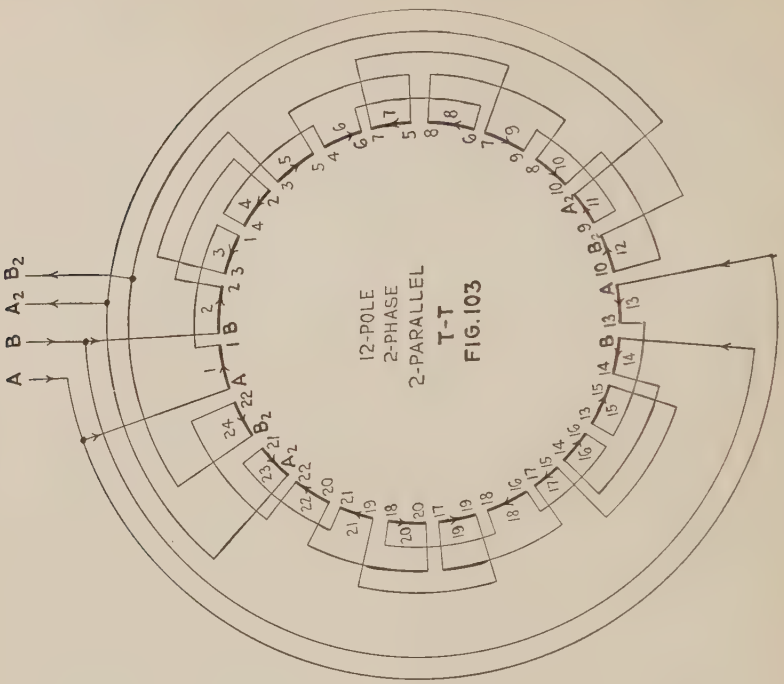
CHART M.—UNEQUAL COIL GROUPING FOR 12-POLE, 2-PHASE WINDINGS

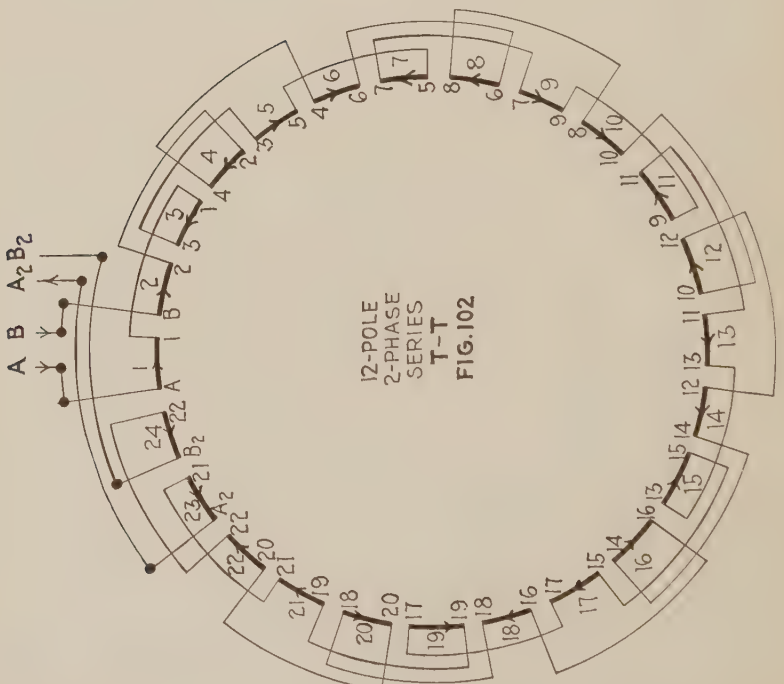
12-pole, 2-phase, top-to-top connections, see Figs. 102, 103, 104, 105, 106 and 113

No. Coils	Group Numbers																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
36	2	2	1	1	2[k]	2[k]	1	1	2	2	1	2	2	2	1	1	2[k]	2[k]	1	1	2	2	1	1
54	3	2	2	2	2	3	2	2	3[k]	2	2	2	2	3	2	2	3	2	2	2	2	3[k]	2	2
60	3[k]	3[k]	2	2	3	3	2	2	3	3	2	2	3[k]	3[k]	2	2	3	3	2	2	3	3	2	2
62	3[k]	3[k]	2	2	3	3	3–1	2	3	3	2	2	3[k]	3[k]	2	2	3	3	2	3–1	3	3	2	2
80	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3
84	4[k]	4[k]	3	3	4	4	3	3	4	4	3	3	4[k]	4[k]	3	3	4	4	3	3	4	4	3	3
86	4[k]	4[k]	3	3	4	4	4–1	3	4	4	3	3	4[k]	4[k]	3	3	4	4	3	4–1	4	4	3	3
90	3	4	4	4	4	3	4	4[k]	3	4	4	4	4	3	4	4	3	4	4[k]	4	4	3	4	4
104	5	4	4	5	4	4	5[k]	4	4	5	4	4	5	4	4	5[k]	4	4	5	4	4	5	4	4
108	5[k]	5[k]	4	4	5	5	4	4	5	5	4	4	5[k]	5[k]	4	4	5	5	4	4	5	5	4	4
128	6	5	5	6	5	5	6[k]	5	5	6	5	5	6	5	5	6[k]	5	5	6	5	5	6	5	5
135	6[k]	6[k]	5	6–1	6	6	5	5	6	6	6–1	5	6[k]	6[k]	5	5	6	6	5	6–1	6	6	5	5
§150	7[k]	6	6	6	6	7	6	6	7	6	6	6	6	7[k]	6	6	7	6	6	6	6	7	6	6
156	7[k]	7[k]	6	6	7	7	6	6	7	7	6	6	7[k]	7[k]	6	6	7	7	6	6	7	7	6	6
160	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7
180	8[k]	8[k]	7	7	8	8	7	7	8	8	7	7	8[k]	8[k]	7	7	8	8	7	7	8	8	7	7

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding (see pages 8–9).

§ All connections can be had by killing one coil in each group of seven coils.


A B A2 B2
12-POLE
2-PHASE
2-PARALLEL
T-T
FIG.103


A B A2B2
12-POLE
2-PHASE
SERIES
T-T
FIG.102

Tables 27 and 28.—Connections for Ends of Groups of 12-pole, 2-phase, *T-T* and *T-B* Windings

Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*).

Table 27.—12-pole, 2-phase, top-to-top. See Figs. 102 to 106 and 112

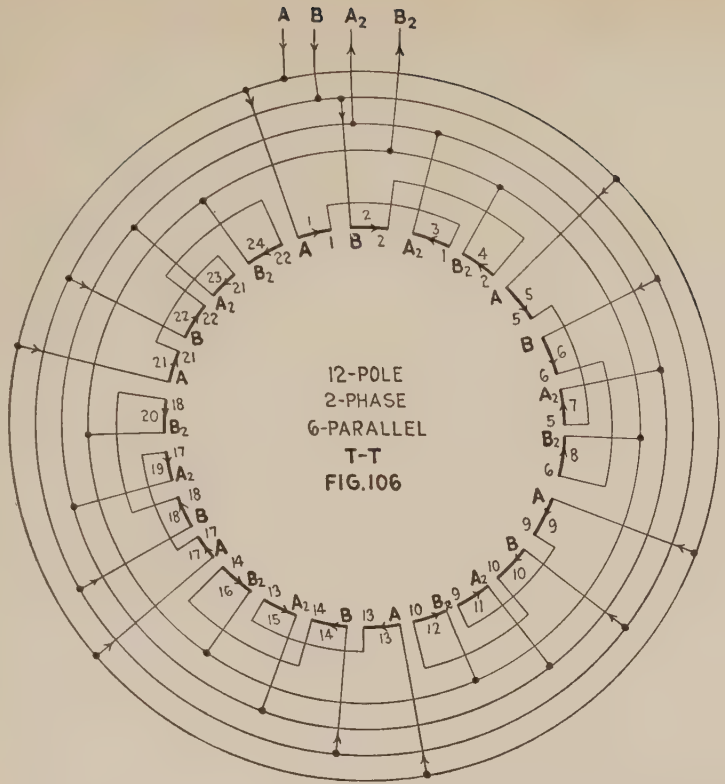
Pole No.		I		II		III		IV		V		VI		VII		VIII		IX		X		XI		XII	
Group No.	Fig.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Series	102	A	1 B	2 3	1 4	2 3	5 4	6 7	5 8	6 7	9 8	10 11	9 12	10 11	13 12	14 15	13 16	14 15	17 16	18 19	17 20	18 19	21 20	22 A_2	21 B_2	22
2 Parallel	103	"	" "	" "	" "	" "	" "	" "	" "	" "	" A_2	" B_2	" A	" B	"	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	"
3 Parallel	104	"	" "	" "	" "	" "	" "	" A_2	" B_2	" A	" B	" 11	" 12	" 11	" 12	" A_2	" B_2	" A	" B	" "	" "	" "	" "	" "	" "	"
4 Parallel	105	"	" "	" "	" "	" "	A_2 "	B_2 7	A 8	B 7	" 8	" A_2	" B_2	" A	" B	" 15	" 16	" 15	A_2 16	B_2 "	A "	B "	" "	" "	" "	"
6 Parallel	106	"	" "	" A_2	" B_2	" A	5 B	6 A_2	5 B_2	6 A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	17 B	18 A_2	17 B_2	18 A	" B	" "	" "	"
12 Parallel	112	"	A_2 "	B_2 A_2	A B_2	B A	A_2 B	B_2 A_2	A B_2	B A	A_2 B	B_2 A_2	A B_2	B A	A_2 B	B_2 A_2	A B_2	B A	A_2 B	B_2 A_2	A B_2	*B* A	A_2 B	B_2 "	A "	B

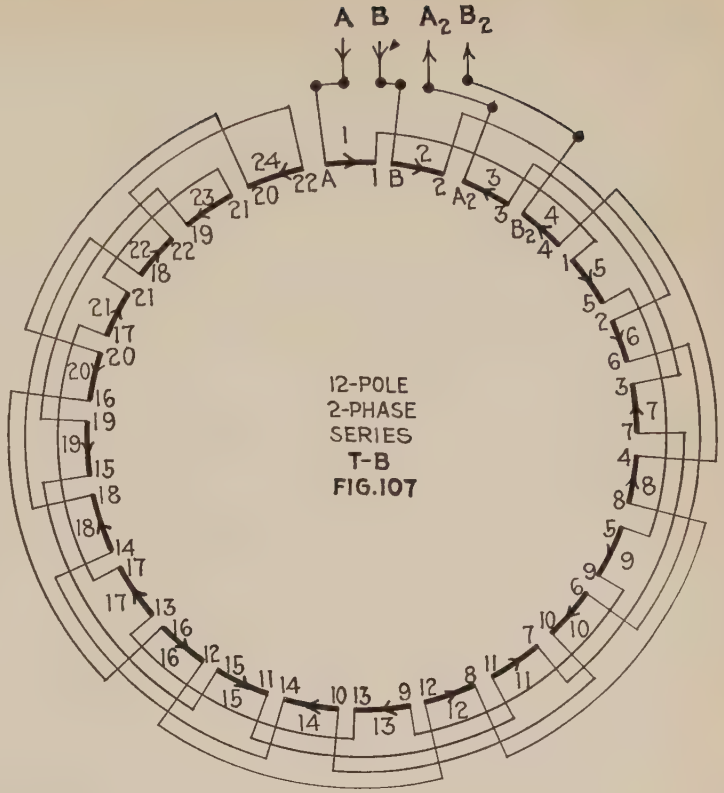
Table 28.—12-pole, 2-phase, top-to-bottom. See Figs. 107 to 112

Series	107	A	1 B	2 A_2	3 B_2	4 1	5 2	6 3	7 4	8 5	9 6	10 7	11 8	12 9	13 10	14 11	15 12	16 13	17 14	18 15	19 16	20 17	21 18	22 19	21 20	22
2 Parallel	108	"	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B
3 Parallel	109	"	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" A_2	" B_2	" A	B A	" B	" A_2	" B_2	" "	21 "	22 "	21 "	22		
4 Parallel	110	"	" "	" "	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B A	13 B	14 A_2	15 B_2	16 13	" 14	" 15	" 16	" "	A_2 "	B_2 "	A "	B
6 Parallel	111	"	" "	" "	" "	" "	A_2 "	B_2 "	A "	B A	9 B	10 A_2	11 B_2	12 9	A_2 10	B_2 11	A 12	B A	" B	" A_2	" B_2	" "	A_2 "	B_2 "	A "	B
12 Parallel	112	"	A_2 "	B_2 "	A "	B A	A_2 B	B_2 A_2	A B_2	B A	A_2 B	B_2 A_2	A B_2	B A	A_2 B	B_2 A_2	A B_2	B A	A_2 B	B_2 A_2	A B_2	B A	A_2 B	B_2 A_2	A B_2	B

A B A2 B2
12-POLE
2-PHASE
3-PARALLEL
T-T
FIG.104

A B A2 B2
12-POLE
2-PHASE
4-PARALLEL
T-T
FIG.105


A B A_2 B_2
12-POLE
2-PHASE
6-PARALLEL
T-T
FIG.106


A B A_2 B_2
12-POLE
2-PHASE
SERIES
T-B
FIG.107

A B A2 B2
12-POLE
2-PHASE
3-PARALLEL
T-B
FIG.109

A B A2 B2
12-POLE
2-PHASE
2-PARALLEL
T-B
FIG.108

A B A2 B2
12-POLE
2-PHASE
4-PARALLEL
T-B
FIG.110

A B A2 B2
12-POLE
2-PHASE
6-PARALLEL
T-B
FIG.111

A B C
12-POLE
3-PHASE
SERIES-STAR
T-T
FIG.113
A B A2 B2
12-POLE
2-PHASE
12-PARALLEL
T-T AND T-B
FIG.112

CHAPTER XXII

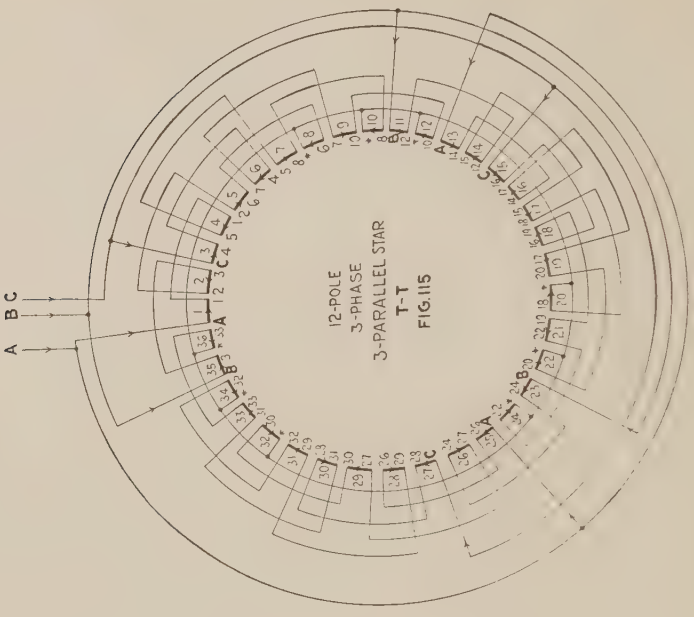
TWELVE-POLE, THREE-PHASE, STAR DIAGRAMS AND CONNECTING TABLES

The connections available are series star and 2-, 3-, 4-, 6- and 12-parallel star.

To change from series star *T-T* (Fig. 113) to 4-parallel star *T-T* (Fig. 116) use Table 29 which shows that jumpers 6, 8 and 10 are cut open and the bottom of groups 5, 7 and 9 connected to the star ring; the bottom of group 8 to the *B* line; the bottom group 10 to the *A* line; the bottom of group 12 to the *C* line. Then jumpers 15, 17 and 19 are cut open and the tops of groups 14, 16 and 18 are connected to the star ring; the top of 17 to *B*; the top of 19 to *A* and the top of 21 to *C* line. Then jumpers 24, 26 and 28 are cut open and the bottom of groups 23, 25 and 27 are connected to the star ring; the bottom of 26 to *B*; the bottom of 28 to *A* and the bottom of 30 to the *C* line. This completes the change.

The changes from one *T-B* to another *T-B* connections are worked out in the same manner. For example, when changing a series-star *T-B* (Fig. 118) to a 2-parallel star *T-B* (Fig. 119) Table 30 shows that the short jumpers 30, 32 and 33 are cut open, the bottom of groups 29, 31 and 33 are connected to the star ring and the bottom of 32 to *B*; the bottom of 34 to *A*, and the bottom of group 36 to the *C* line.

The change from a star to any delta winding can also be made by using the proper figures and tables, as explained in the proceeding chapters.


A B C
12-POLE
3-PHASE
3-PARALLEL STAR
T-T
FIG.115

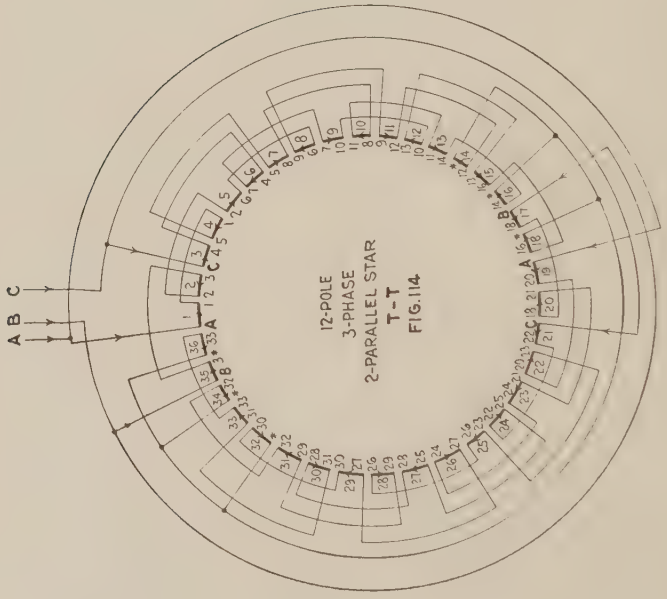

A B C
12-POLE
3-PHASE
2-PARALLEL STAR
T-T
FIG.114

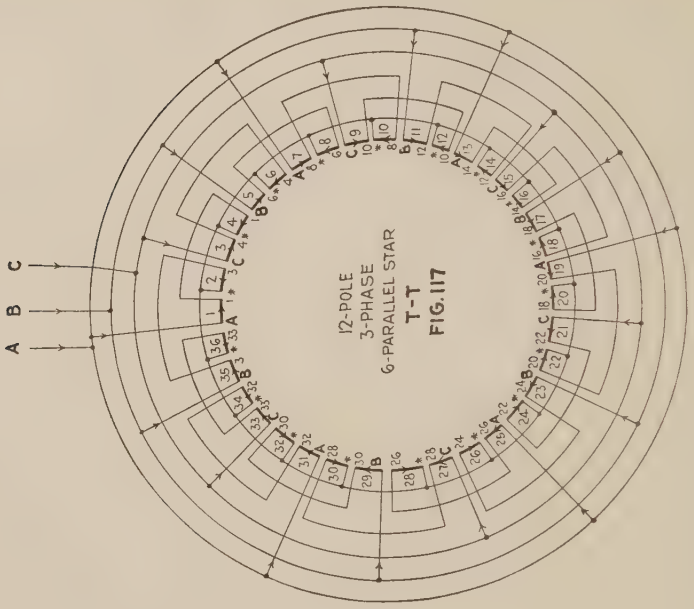
TABLE 29.—CONNECTIONS FOR ENDS OF GROUPS FOR 12-POLE, 3-PHASE STAR *T-T* WINDINGS

Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*).

12-pole, 3-phase, Star, Top-to-top. See Figs. 113 to 117 and 123

Pole Number.....		I			II			III			IV			V			VI		
Group No.	Fig.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series.....	113	A	1 2	3 C	4 5	1 2	6 7	4 5	8 9	6 7	10 11	8 9	12 13	10 11	14 15	12 13	16 17	14 15	18 19	16
2 Parallel....	114	"	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" *	" "	" *	" B	" *	"
3 Parallel....	115	"	" "	" "	" "	" "	" "	" "	" *	" "	" *	" B	" *	" A	" 15	" C	" 17	" 15	" 19	"
4 Parallel....	116	"	" "	" "	" "	" "	" *	" "	" 9	B "	* 11	A 9	" 13	C 11	" *	" 13	" *	" B	" *	"
6 Parallel....	117	"	" *	" "	" *	" B	" *	" A	" *	6 C	10 *	8 B	" *	10 A	" *	" C	" *	" B	" *	"
12 Parallel....	123	"	* *	B "	* *	A B	* *	C A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C

Pole Number.....		VII			VIII			IX			X			XI			XII		
Group No.		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Series.....		17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	* 30	31 33	* 32	B 3	* 33
2 Parallel.....		A "	" "	C "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	"
3 Parallel.....		17 "	* "	19 "	* "	B "	* "	A "	" "	C "	" "	" "	" "	" "	" "	" "	" "	" "	" "	"
4 Parallel.....		A "	21 "	C "	23 "	21 *	25 "	23 *	" B	25 *	" A	" "	" C	" "	" "	" "	" "	" "	" "	"
6 Parallel.....		A "	* "	C "	* "	B 24	* "	A 26	* 24	C 28	* 26	B "	* 28	A "	" "	C "	" "	" "	" "	"
12 Parallel.....		A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	" B	C *	" A	" *	" C	


A B C
12-POLE
3-PHASE
6-PARALLEL STAR
T-T
FIG. 117

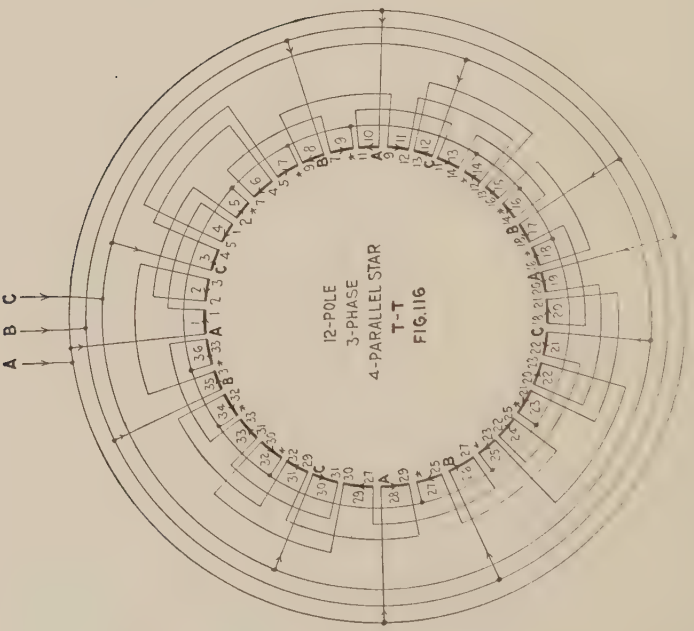
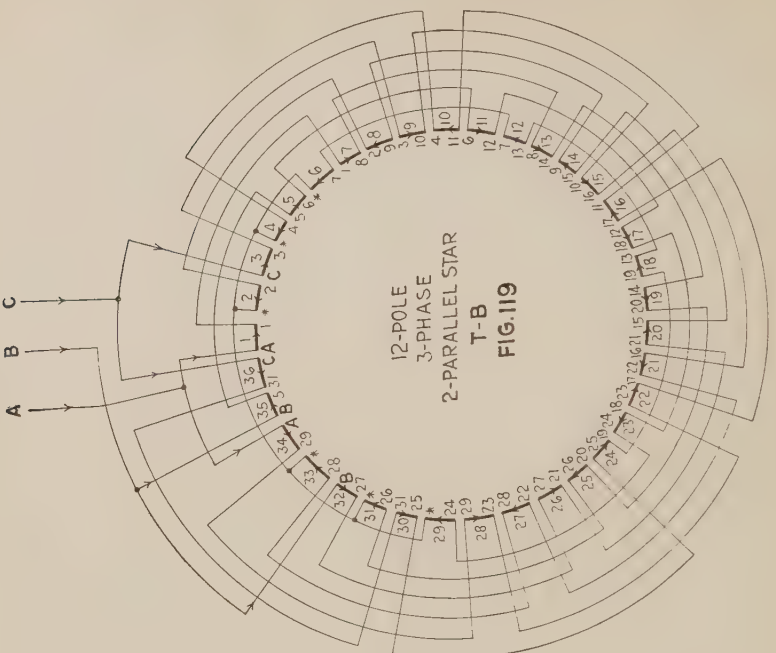

A B C
12-POLE
3-PHASE
4-PARALLEL STAR
T-T
FIG. 116

CHART N(1).—UNEQUAL COIL GROUPING (TOP-TO-TOP) FOR 12-POLE, 3-PHASE WINDINGS

For star connections, see Figs. 113, 114, 115, 116, 117 and 123. For delta connections, see Figs. 124, 125, 126, 127, 128 and 134.

No. Coils	Group Numbers											
	1 2 3	4 5 6	7 8 9	10 11 12	13 14 15	16 17 18	19 20 21	22 23 24	25 26 27	28 29 30	31 32 33	34 36 36
48	2 1 1	1 1 2	1 2 1	2 1 1	1 1 2	1 2 1	2 1 1	1 1 2	1 2 1	2 1 1	1 1 2	1 2 1
54	2 1 2	1 2 1	1 2 1	2 1 2	2 1 2	1 2 1	1 2 1	2 1 2	2 1 2	1 2 1	1 2 1	2 1 2
60	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2
62	1 2 2	2 2 1	2 2–1 2	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2	3–1 2 2	2 2 1	2 1 2
80	3 2 2	2 3 1 2	2 3 2	2 2 2	2 2 3	2 2 2	3 2 2	2 3–1 2	2 3 2	2 2 2	2 2 3	2 2 2
84	3 2 2	2 2 3	2 3 2	3 2 2	2 2 3	2 3 2	3 2 2	2 2 3	2 3 2	3 2 2	2 2 3	2 3 2
90	3 2 3	2 3 2	2 3 2	3 2 3	3 2 3	2 3 2	2 3 2	3 2 3	3 2 3	2 3 2	2 3 2	3 2 3
96	2 3 3	3 3 2	3 2 3	2 3 3	3 3 2	3 2 3	2 3 3	3 3 2	3 2 3	2 3 3	3 3 2	3 2 3
104	2 3 3	3 3 3	3 3–1 3	3 3 3	3 3 2	3 3 3	2 3 3	3 3 3	3 2 3	3 3 3	3 3 3–1	3 3 3
120	4 3 3	3 3 4	3 4 3	4 3 3	3 3 4	3 4 3	4 3 3	3 3 4	3 4 3	4 3 3	3 3 4	3 4 3
128	4 3 4	3 4 3	3 4 3	4 4–1 4	4 3 4	3 4 3	3 4 3	4 3 4	4 4–1 4	3 4 3	3 4 3	4 3 4
135	3 4[k] 4	4 3 4[k]	4 4 3	4[k] 4 4	3 4[k] 4	4 3 4[k]	4 4 3	4[k] 4 4	3 4[k] 4	4 3 4[k]	4 4 3	4[k] 4 4
150	5[k] 4 4	4 4 4	4 5[k] 4	4 4 4	4 4 5[k]	4 4 4	5[k] 4 4	4 4 4	4 5[k] 4	4 4 4	4 4 5[k]	4 4 4
156	5 4 4	4 4 5	4 4 5	5 4 4	4 4 5	4 5 4	5 4 4	4 4 5	4 5 4	5 4 4	4 4 5	4 5 4
160	4 5 4	5–1 4 5	5 4 5	4 4 4	4 4 4	5 5–1 4	5 4 5–1	4 5 4	4 5 4	5 4 5	5–1 4 5	4 5 4
168	4 5 5	5 5 4	5 4 5	4 5 5	5 5 4	5 4 5	4 5 5	5 5 4	5 4 5	4 5 5	5 5 4	5 4 5
240	6 7 7	7 7 6	7 6 7	6 7 7	7 7 6	7 6 7	6 7 7	7 7 6	7 6 7	6 7 7	7 7 6	7 6 7

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding (see pages 8–9).


A B C
12-POLE
3-PHASE
2-PARALLEL STAR
T-B
FIG.119

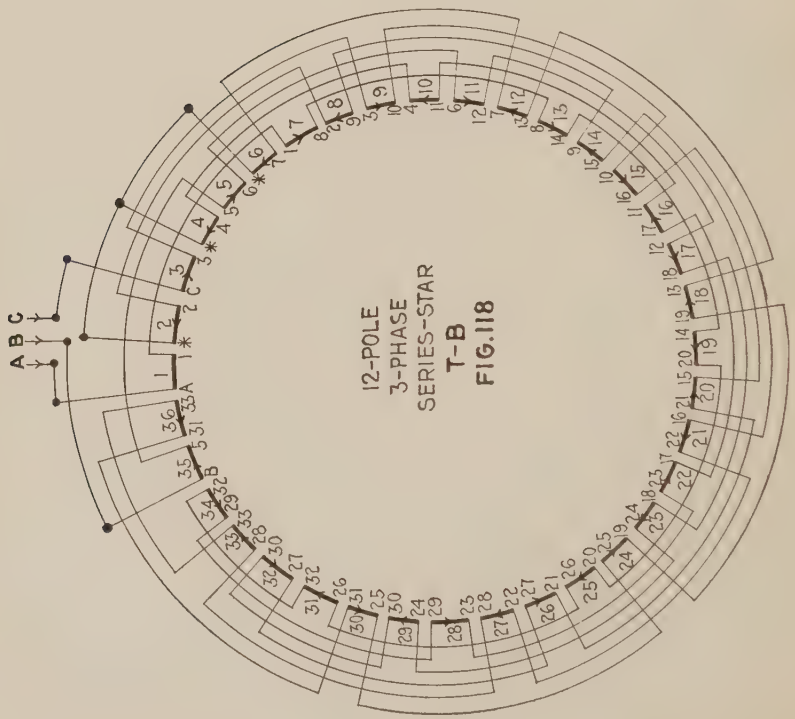

A B C
12-POLE
3-PHASE
SERIES-STAR
T-B
FIG.118

TABLE 30.—CONNECTIONS FOR ENDS OF GROUPS FOR 12-POLE, 3-PHASE, STAR *T-B* WINDINGS

Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*).

12-pole, 3-phase, Star, Top-to-bottom. See Figs. 118, 119, 120, 121, 122, 123

Pole Number.....		I					II					III					IV					V					VI				
Group No.	Fig.	1		2		3	4		5		6	7		8		9	10		11		12	13		14		15	16		17		18	
Series.....	118	A	1	*	2	C	3	*	4	5	6	*	7	1	8	2	9	3	10	4	11	6	12	7	13	8	14	9	15	10	16	11	17	12	18	13	19
2 Parallel....	119	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
3 Parallel....	120	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	*	"	"
4 Parallel....	121	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	*	"	"	"	*	"	B	"	*	"	A	B	18	"	C		
6 Parallel....	122	"	"	"	"	"	"	"	"	*	"	"	"	*	"	B	"	*	"	A	B	12	"	C	A	14	*	15	C	16	*	17	12	*	*	19	
12 Parallel....	123	"	*	"	B	"	*	"	A	B	*	"	C	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C

Pole Number.....		VII					VIII					IX					X					XI					XII				
Group No.		19		20		21	22		23		24	25		26		27	28		29		30	31		32		33	34		35		36	
Series.....		14	20	15	21	16	22	17	23	18	24	19	25	20	26	21	27	22	28	23	29	24	30	25	31	26	32	27	30	28	33	29	32	B	5	31	33
2 Parallel.....		"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	*	"	"	"	*	"	B	"	*	"	A	"	"	"	C
3 Parallel.....		"	*	"	B	"	*	"	A	B	"	"	C	A	"	*	"	C	"	*	"	"	30	*	"	"	32	"	30	"	33	"	32	"	"	"	33
4 Parallel.....		A	20	*	21	C	22	*	23	18	"	*	25	20	"	21	"	22	"	23	"	"	*	25	"	"	*	"	B	"	*	"	A	"	"	"	C
6 Parallel.....		14	*	15	B	16	*	17	A	B	"	19	C	A	"	*	"	C	"	*	"	"	*	*	"	"	*	"	B	"	*	"	A	"	"	"	C
12 Parallel.....		A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	"	*	*	C

A B C
12-POLE
3-PHASE
4-PARALLEL STAR
T-B
FIG.121

A B C
12-POLE
3-PHASE
3-PARALLEL STAR
T-B
FIG.120

A B C
12-POLE
3-PHASE
12-PARALLEL STAR
T-TANDT-B
FIG.123

A B C
12-POLE
3-PHASE
6-PARALLEL STAR
T-B
FIG.122

CHART N(2).—UNEQUAL COIL GROUPING (TOP-TO-BOTTOM) FOR 12-POLE, 3-PHASE WINDINGS

For star connections see Figs. 118, 119, 120, 121, 122, 123. For delta connections see Figs. 129, 130, 131, 132, 133, 134.

No. Coils	Group Numbers											
	1 2 3	4 5 6	7 8 9	10 11 12	13 14 15	16 17 18	19 20 21	22 23 24	25 26 27	28 29 30	31 32 33	34 35 36
48	2[k] 1 1	1 1 2	1 2 1	2 1 1	1 1 2[k]	1 2 1	2 1 1	1 1 2	1 2[k] 1	2 1 1	1 1 2	1 2 1
54	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1
60	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2
62	1 2 2	2 2 1	2 2–1 2	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2	2–1 2 2	2 2 1	2 1 2
80	3 2 2	2 3–1 2	2 2 3	2 2 2	2 3 2	2 2 2	3 2 2	2 2 3–1	2 2 3	2 2 2	2 3 2	2 2 2
84	3[k] 2 2	2 2 3	2 3 2	3 2 2	2 2 3[k]	2 3 2	3 2 2	2 2 3	2 3[k] 2	3 2 2	2 2 3	2 3 2
86	3[k] 2 2	2 2 3	2 3 2	3 2 3–1	2 2 3[k]	2 3 2	3 2 2	3–1 2 3	2 3[k] 2	3 2 2	2 2 3	2 3 2
90	3[k] 2 3	2 3 2	3 2 3[k]	2 3[k] 2	3 2 3	2 3 2	3[k] 2 3	2 3 2	3 2 3[k]	2 3[k] 2	3 2 3	2 3 2
96	2 3[k] 3	3 3 2	3 2 3	2 3 3[k]	3[k] 3 2	3 2 3	2 3[k] 3	3 3 2	3 2 3	2 3 3[k]	3[k] 3 2	3 2 3
104	2 3[k] 3	3 3 3	3 3 2	3 3 3[k]	3[k]3–1 3	3 3 3	2 3[k] 3	3 3 3	3 3 3–1	3 3 3[k]	3[k] 2 3	3 3 3
120	4[k] 3 3	3 3 4	3 4 3	4 3 3	3 3 4[k]	3 4 3	4 3 3	3 3 4	3 4[k] 3	4 3 3	3 3 4	3 4 3
128	4[k] 3 4[k]	3 4 3	4 4–1 4	3 4[k] 3	4 3 4	3 4 3	4[k] 3 4[k]	3 4 4–1	4 3 4	3 4[k] 3	4 3 4	3 4 3
135	3 4 4	4 3 4	4 4 3	4 4 4[k]	3 4 4	4 3 4	4 4 3	4 4[k] 4	3 4 4	4 3 4	4 4 3	4[k] 4 4
150	5[k] 4 4	4 4 4	4 4 5[k]	4 4 4	4 5[k] 4	4 4 4	5[k] 4 4	4 4 4	4 4 5[k]	4 4 4	4 5[k] 4	4 4 4
156	5[k] 4 4	4 4 5	4 5 4	5 4 4	4 4 5[k]	4 5 4	5 4 4	4 4 5	4 5[k] 4	5 4 4	4 4 5	4 5 4
160	5[k] 4 5–1	4 4 5	4 5 4	5 5–1 4	4 4 5[k]	4 5 4	5 4 5–1	4 4 5	4 5[k] 4	5 4 5–1	4 4 5	4 5 4
168	4 5[k] 5	5 5 4	5 4 5[k]	4 5 5	5[k] 5 4	5 4 5	4 5[k] 5	5 5 4	5 4 5[k]	4 5 5	5[k] 5 4	5 4 5
240	6 7[k] 7	7 7 6	7 6 7[k]	6 7 7	7[k] 7 6	7 6 7	6 7[k] 7	7 7 6	7 6 7[k]	6 7 7	7[k] 7 6	7 6 7

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding (see pages 8–9).

CHAPTER XXIII

TWELVE-POLE, THREE-PHASE, DELTA DIAGRAMS AND CONNECTING TABLES

This chapter makes use of the coil grouping chart given in Chapter 22.

When changing from series-delta *T-T* (Fig. 124) to a 4-parallel delta *T-T* connection (Fig. 127), Table 31 and Fig. 127 show that three lead rings are added. Then the tops of groups 18 and 19 and bottoms of groups 9, 10, 27 and 28 are connected to the *A* ring, the tops of groups 16 and 17 and bottoms of groups 7, 8, 25 and 26 are connected to the *B* ring, and the tops of groups 14 and 21 and bottoms of groups 5, 12, 23 and 30 are connected to the *C* ring.

From the above it is obvious that a delta reconnection of this nature is less confusing than a corresponding star change.

A B C
12-POLE
3-PHASE
3-PARALLEL DELTA
T-T
FIG.125

A B C
12-POLE
3-PHASE
SERIES-DELTA
T-T
FIG.124

TABLE 31.—CONNECTIONS FOR ENDS OF GROUPS FOR 12-POLE, 3-PHASE DELTA *T-T* WINDINGS

Connect together ends having same number or letter. Line leads are indicated by letters. 12-pole, 3-phase, Delta, Top-to-top

See Figs. 124, 125, 126, 127, 128 and 134

Pole Number		I			II			III			IV			V			VI		
Group No.	Fig.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	124	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16
2 Parallel	125	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	C "	" "	B "	B "	A "
3 Parallel	126	" "	" "	" "	" "	" "	" "	" C	" "	" "	B "	B "	A "	A "	15 "	C "	17 "	15 "	19 "	
4 Parallel	127	" "	" "	" "	" "	" C	" "	" B	9 B	" A	11 A	9 "	13 C	11 "	C "	13 "	B "	B "	A "	
6 Parallel	128	" C	" "	" "	B "	B 6	A "	A 8	C 6	C 10	B 8	B "	A 10	A "	C "	C "	B "	B "	A "	
12 Parallel	134	" B	C B	" A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	

Pole Number		VII			VIII			IX			X			XI			XII		
Group No.		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Series		17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	C 30	31 33	B 32	B 3	A 33
2 Parallel		A "	" "	C "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
3 Parallel		17 "	C "	19 "	B "	B "	A "	A "	" "	C "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
4 Parallel		A "	21 "	C "	23 "	21 C	25 "	23 B	" B	25 A	" A	" "	" C	" "	" "	" "	" "	" "	" "	" "	" "
6 Parallel		A "	C "	C "	B "	B 24	A "	A 26	C 24	C 28	B 26	B "	A 28	A "	" "	C "	" "	" "	" "	" "	" "
12 Parallel		A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	" B	C A	" A	" C	" C		

A B C
12-POLE
3-PHASE
3-PARALLEL DELTA
T-T
FIG.126

A B C
12-POLE
3-PHASE
4-PARALLEL DELTA
T-T
FIG.127

A B C
12-POLE
3-PHASE
6-PARALLEL DELTA
T-T
FIG.128

A B C
12-POLE
3-PHASE
SERIES-DELTA
T-B
FIG.129

A B C
12-POLE
3-PHASE
3-PARALLEL DELTA
T-B
FIG.131

A B C
12-POLE
3-PHASE
2-PARALLEL DELTA
T-B
FIG.130

TABLE 32.—CONNECTIONS FOR ENDS OF GROUPS FOR 12-POLE, 3-PHASE, DELTA *T-B* WINDINGS

Connect together ends having the same number or letter. Letters indicate line leads. 12-pole, 3-phase, Delta, Top-to-bottom.

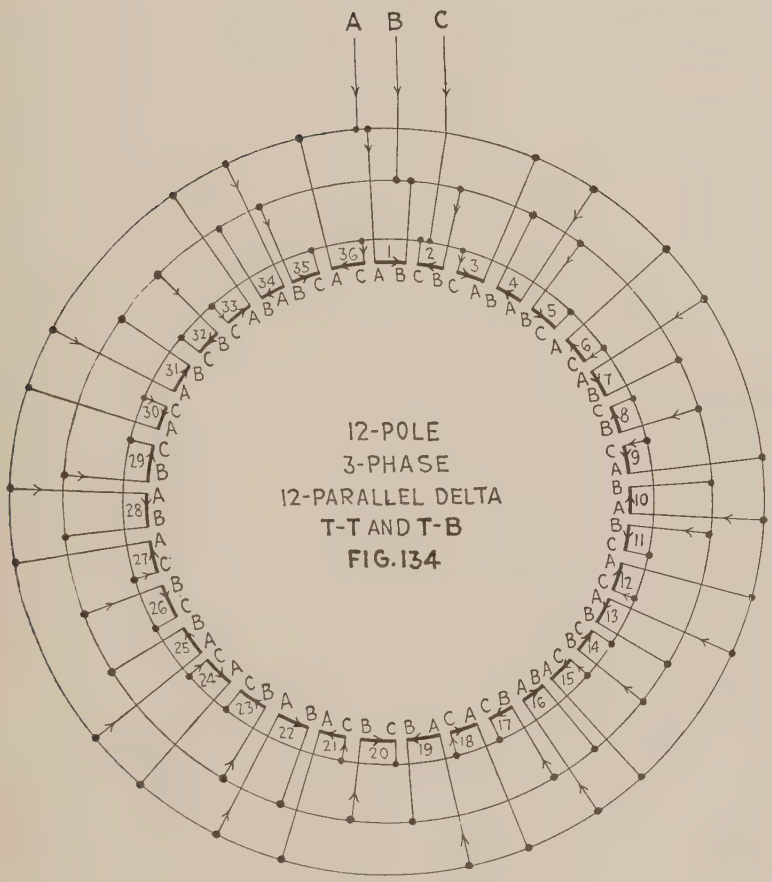
See Figs. 129, 130, 131, 132, 133, 134

Pole Number.....		I			II			III			IV			V			VI		
Group No.	Fig.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series.....	129	A 1	C 2	C 3	B 4	5 6	A 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 18	13 19
2 Parallel....	130	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
3 Parallel....	131	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" C	" "
4 Parallel....	132	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" C	" "	" B	" B	" A	" A	B "	" C
6 Parallel....	133	" "	" "	" "	" "	" C	" "	" B	" B	" A	" A	B 12	" C	A 14	C 15	C 16	B 17	12 C	A 19
12 Parallel....	134	" B	" B	" A	" A	B C	" C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C

Pole Number.....		VII			VIII			IX			X			XI			XII		
Group No.		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Series.....		14 20	15 21	16 22	17 23	18 24	19 25	20 26	21 27	22 28	23 29	24 30	25 31	26 32	27 30	28 33	29 32	B 5	31 33
2 Parallel.....		" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" C	" "	" B	" B	" A	" A	" "	" C
3 Parallel.....		" B	" B	" A	" A	B "	" C	A "	C "	C "	B "	" 30	A "	" 32	" 30	" 33	" 32	" "	" 33
4 Parallel.....		A 20	C 21	C 22	B 23	18 "	A 25	20 "	21 "	22 "	23 "	" C	25 "	" B	" B	" A	" A	" "	" C
6 Parallel.....		14 B	15 B	16 A	17 A	B "	19 C	A "	C "	C "	B "	" C	A "	" B	" B	" A	" A	" "	" C
12 Parallel.....		A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	" C	A C

A B C
12-POLE
3-PHASE
6-PARALLEL DELTA
T-B
FIG.133

A B C
12-POLE
3-PHASE
4-PARALLEL DELTA
T-B
FIG.132


A B C
12-POLE
3-PHASE
12-PARALLEL DELTA
T-T AND T-B
FIG. 134

CHAPTER XXIV

FOURTEEN-POLE, TWO- AND THREE-PHASE, STAR AND DELTA DIAGRAMS AND CONNECTING TABLES

This chapter shows only the *T-T* type of diagram. For 2-phase motors there are four connections possible; namely, series, 2-, 7- and 14-parallel and the majority of reconnecting problems will be from series to 2-parallel or vice versa. The use of the tables in conjunction with the diagrams for reconnecting has been explained in the previous chapters.

When changing to a 7- or 14-parallel connection considerable time can be saved if four lead rings are used.

For 3-phase star motors this chapter includes a connecting table and odd grouping chart. The diagrams and tables will enable the following reconnection to be made, as required: series-star, 2-, 7- and 14-parallel star. Also a star connection can be changed to a delta connection by comparing the tables and data.

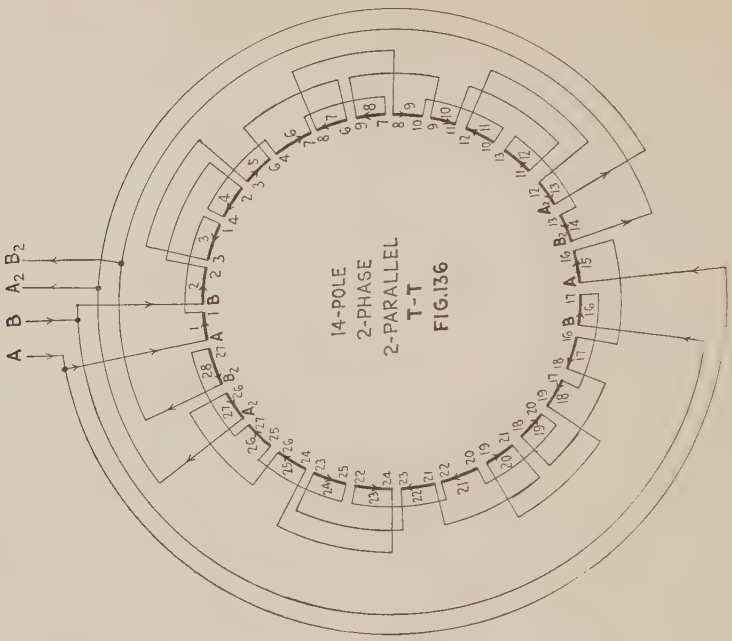
For 3-phase, delta-connected motors, the odd coil grouping given in Chapter 23 for the 14-pole, 3-phase, star connections is also used in connection with the diagrams given in this chapter. The diagrams and tables in this chapter show how any connection, such as series to 2-parallel or delta to star, etc. is made.

Chart P.—Unequal Coil Grouping for 14-pole, 2-phase *T-T* Windings

14-pole, 2-phase, Top-to-top

Coils	Group Numbers																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
36	1	1	1	1	2	1	1	2	1	1	2	1	1	2	1	1	1	1	2	1	1	2	1	1	2	1	1	2
48	2	2	2	2	1	2	2	1	2	2	1	2	2	1	2	2	2	2	1	2	2	1	2	2	1	2	2	1
54	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2
60	3	2	2	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	2	2
62	3	2	2	2	3–1	2	2	3	2	2	2	2	2	2	3	2	2	2	3–1	2	2	3	2	2	2	2	2	2
72	2	3	2	3	3	2	3	2	3	2	3	3	2	3	2	3	2	3	3	2	3	2	3	2	3	3	2	3
80	2	3	3	3	3	3	3	2	3	3	3	3	3	3	2	3	3	3	3	3	3	2	3	3	3	3	3	3
86	4–1	3	3	3	3	3	3	3	3	3	3	3	3	3	4–1	3	3	3	3	3	3	3	3	3	3	3	3	3
90	4	3	3	3	3	3	3	4	3	3	4–1	3	3	3	4	3	3	3	3	3	3	4	3	3	3	4–1	3	3
96	4	3	4	3	3	4	3	4	3	4	3	3	4	3	4	3	4	3	3	4	3	4	3	4	3	3	4	3
104	4	4	4	4	3	4	4	3	4	4	3	4	4	3	4	4	4	4	3	4	4	3	4	4	3	4	4	3
108	3	4	4	4	4	4	4	3	4	4	4	4	4	4	3	4	4	4	4	4	4	3	4	4	4	4	4	4
120	4	4	4	4	5[k]	4	4	5[k]	4	4	5[k]	4	4	5[k]	4	4	4	4	5[k]	4	4	5[k]	4	4	5[k]	4	4	5[k]
128	4	5	4	5	5	4	5	4	5	4	5	5	4	5	4	5	4	5	5	4	5	4	5	4	5	5	4	5
135	5	5	5	5	5–1	5	5	4	5	5	4	5	5	5–1	5	5	5	5	4	5	5	5–1	5	5	4	5	5	4
144	6	5	5	5	5	5	5	6	5	5	5	5	5	5	6	5	5	5	5	5	5	6	5	5	5	5	5	5
150	6–1	5	5	5	6	5	5	6	5	5	6	5	5	6	5	6–1	5	5	6	5	5	6	5	5	6	5	5	6
156	5	6	5	6	6	5	6	5	6	5	6	6	5	6	5	6	5	6	6	5	6	5	6	5	6	6	5	6
160	6	6	6	6	5	6	6	5	6	6	5	6	6	5	6	6	6	6	5	6	6	5	6	6	5	6	6	5
180	7	6	7	6	6	7	6	7	6	7	6	6	7	6	7	6	7	6	6	7	6	7	6	7	6	6	7	6
216	8	8	8	8	7	8	8	7	8	8	7	8	8	7	8	8	8	8	7	8	8	7	8	8	7	8	8	7
240	8	9	8	9	9	8	9	8	9	8	9	9	8	9	8	9	8	9	9	8	9	8	9	8	9	9	8	9

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding (see pages 8–9).


A B A2 B2
14-POLE
2-PHASE
2-PARALLEL
T-T
FIG.136

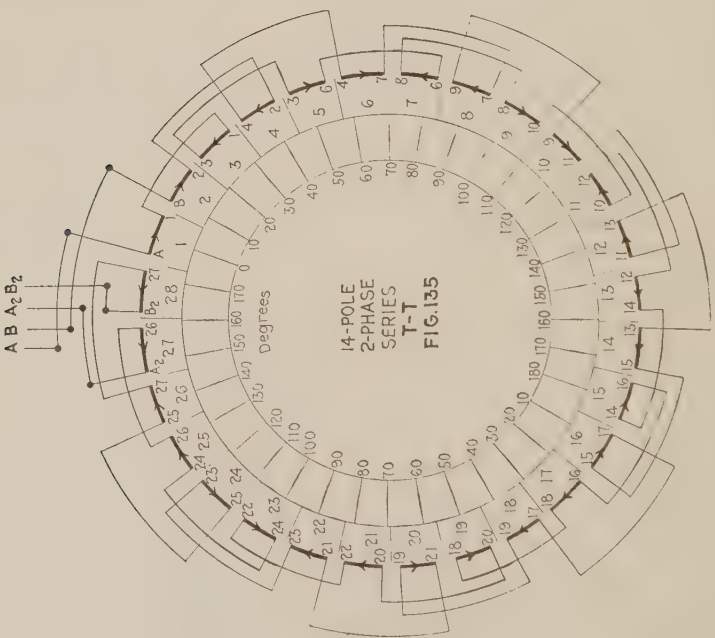

A B A2 B2
Degrees
14-POLE
2-PHASE
SERIES
T-T
FIG.135

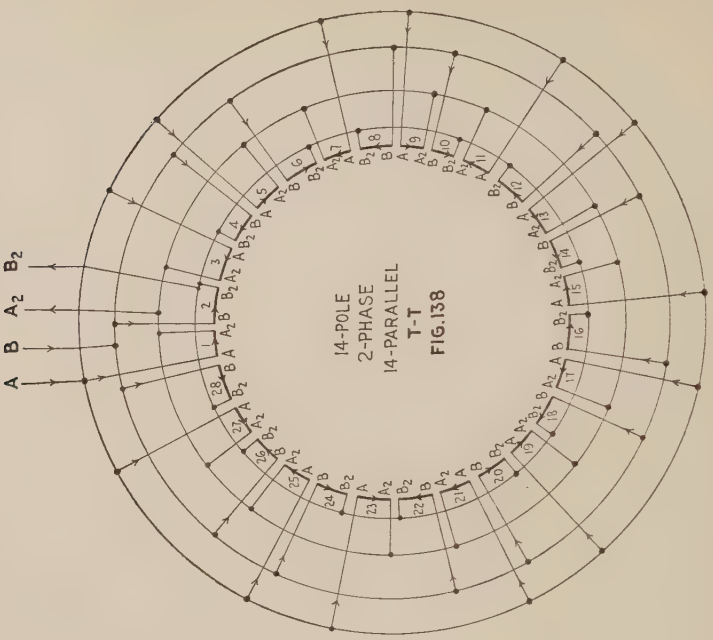
TABLE 33.—CONNECTIONS FOR ENDS OF GROUPS FOR 14-POLE, 2-PHASE, *T-T* WINDINGS

Connect together group ends having same number or letter. Line leads are indicated by letters.

14-pole, 2-phase, Top-to-top. See Figs. 135, 136, 137, 138

Pole Number		I		II		III		IV		V		VI		VII	
Group Number	Fig.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Series	135	A 1	B 2	3 1	4 2	3 6	4 7	8 6	9 7	8 10	9 11	12 10	13 11	12 14	13 15
2 parallel	136	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" A_2	" B_2
7 parallel	137	" "	" "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A 14	B 15
14 parallel	138	" A	" B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2

Pole Number		VIII		IX		X		XI		XII		XIII		XIV	
Group Number		15	16	17	18	19	20	21	22	23	24	25	26	27	28
Series		16 14	17 15	16 18	17 19	20 18	21 19	20 22	21 23	24 22	25 23	24 26	25 27	A_2 26	B_2 27
2 parallel		" A	" B	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
7 parallel		A_2 14	B_2 15	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	" "	" "
14 parallel		A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	" A	" B


A B A2 B2
14-POLE
2-PHASE
14-PARALLEL
T-T
FIG.138

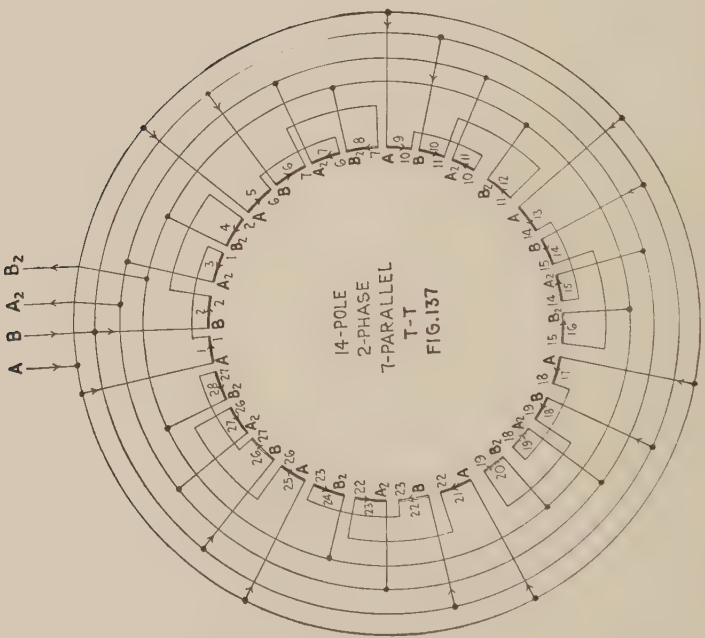
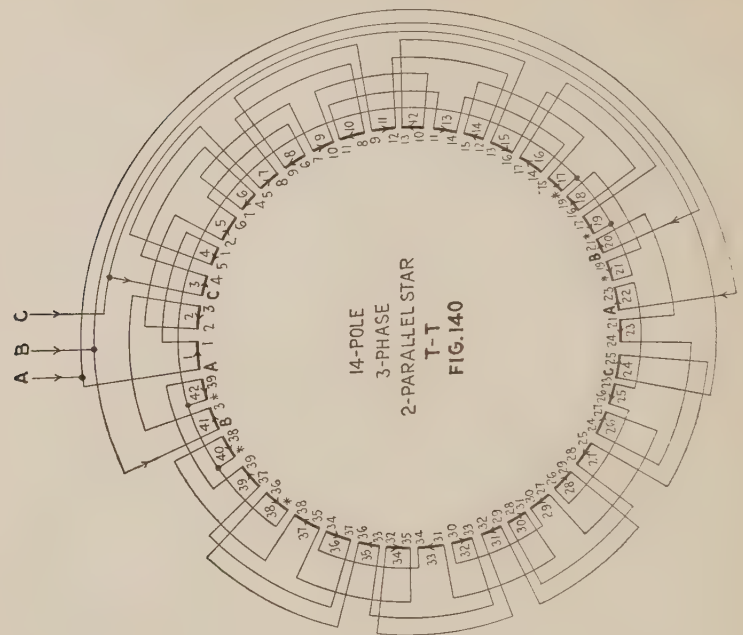

A B A2 B2
14-POLE
2-PHASE
7-PARALLEL
T-T
FIG.137

Chart Q.—Unequal Coil Grouping for 14-pole, 3-phase *T-T* Windings

14-pole, 3-phase, Top-to-top. Star and Delta Connections

| Coils | Group Numb | | |


14-POLE
3-PHASE
2-PARALLEL STAR
T-T
FIG. 140
A B C

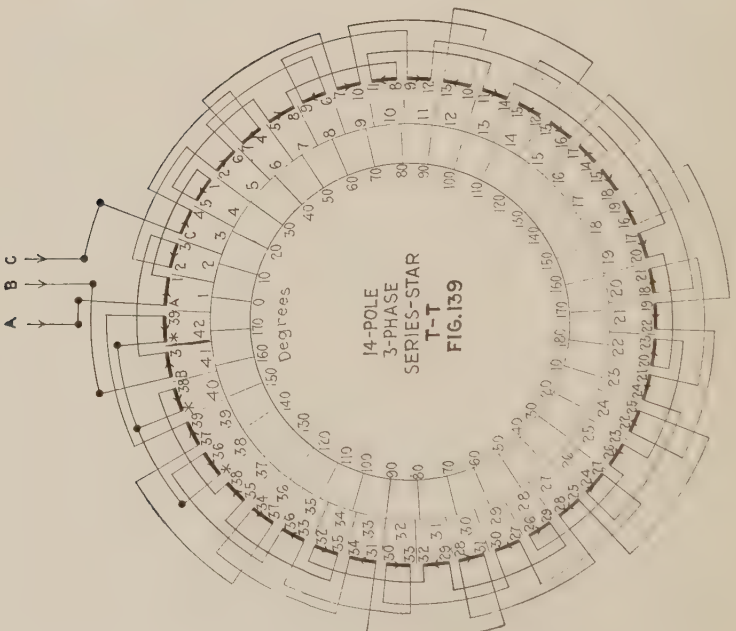

14-POLE
3-PHASE
SERIES-STAR
T-T
FIG. 139
Degrees
A B C

TABLE 34.—CONNECTIONS FOR ENDS OF GROUPS FOR 14-POLE, 3-PHASE, STAR *T-T* WINDINGS

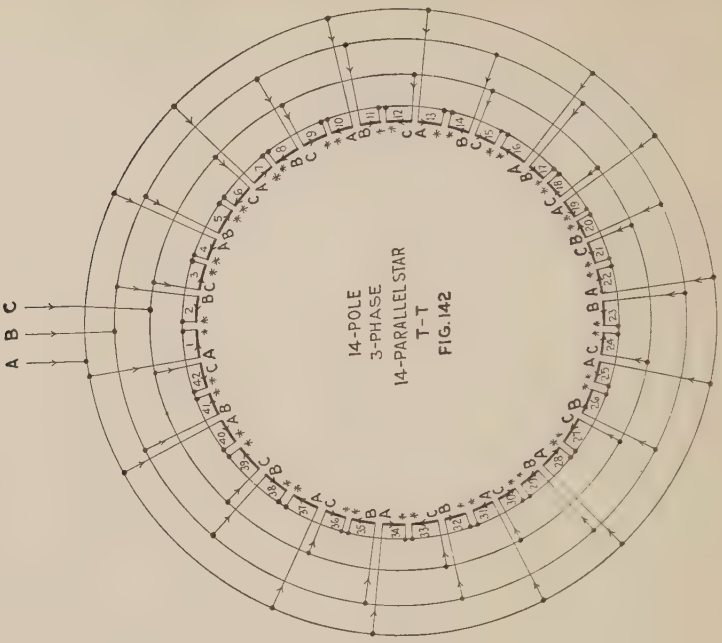
Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is shown by (*).

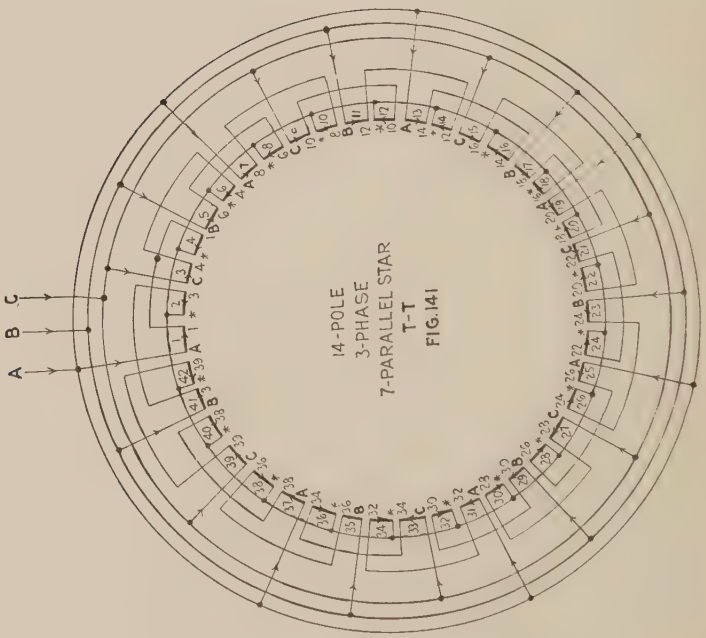
14-pole, 3-phase Star, Top-to-top. See Figs. 139, 140, 141, 142

Pole Number		I			II			III			IV			V		
Group Number	Fig.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Series	139	A	1 2	3 C	4 5	1 2	6 7	4 5	8 9	6 7	10 11	8 9	12 13	10 11	14 15	12 13	16
2-parallel	140	"	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	"
7-parallel	141	"	" *	" "	" *	" B	" *	" A	" *	" C	" *	" B	" *	" A	" *	" C	"
14-parallel	142	"	* *	B "	* *	A B	* *	C A	* *	B C	* *	A B	* *	C A	* *	B C	*

Pole Number		VI			VII			VIII			IX			X		
Group Number		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Series	17	14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28
2-parallel	"	"	" *	" "	" *	" B	" *	" A	" "	" C	" "	" "	" "	" "	" "	" "	"
7-parallel	*	"	B 18	* "	A 20	* 18	C 22	* 20	B "	* 22	A "	* "	C "	* "	B "	* "	
14-parallel	*	A	B *	* C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C	

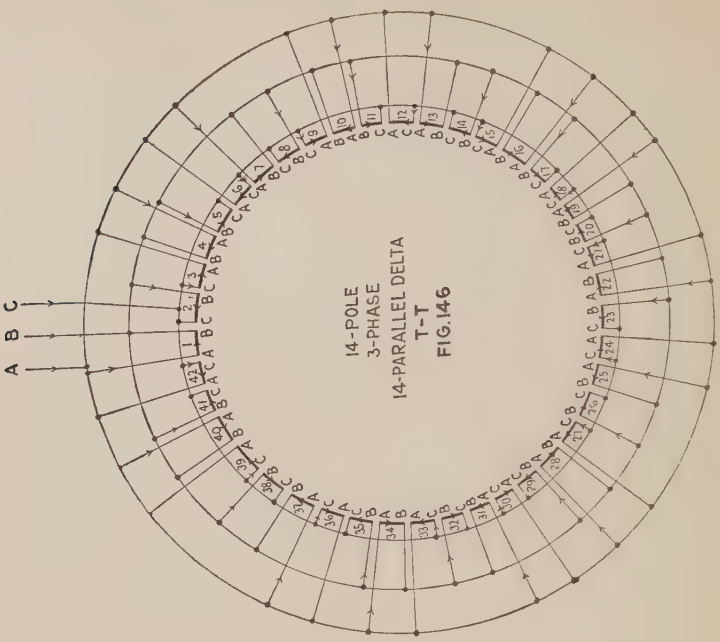
Pole Number		XI			XII			XIII			XIV		
Group Number		31	32	33	34	35	36	37	38	39	40	41	42
Series	29	32	33 30	31 34	35 32	33 36	37 34	35 38	* 36	37 39	* 38	B 3	* 39
2-parallel	"	"	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
7-parallel	A	"	* "	C "	* "	B "	* "	A "	" "	C "	" "	" "	" "
14-parallel	A	*	* B	C *	* A	B *	* C	A *	" B	C *	" A	" "	" C


A B C
14-POLE
3-PHASE
14-PARALLEL STAR
T-T
FIG. 142


A B C
14-POLE
3-PHASE
7-PARALLEL STAR
T-T
FIG. 141

A B C
14-POLE
3-PHASE
2-PARALLEL DELTA
T-T
FIG. 144

A B C
14-POLE
3-PHASE
SERIES-DELTA
T-T
FIG. 143


A B C
14-POLE
3-PHASE
14-PARALLEL DELTA
T-T
FIG. 146

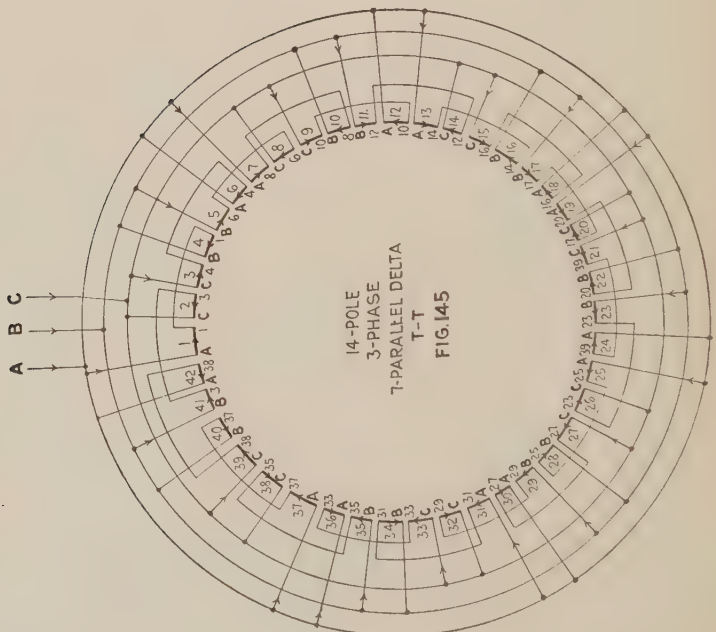

A B C
14-POLE
3-PHASE
7-PARALLEL DELTA
T-T
FIG. 145

TABLE 35.—CONNECTIONS FOR ENDS OF GROUPS 14-POLE, 3-PHASE, DELTA *T-T* WINDINGS

Connect together group ends having same number or letter. Line leads are indicated by letters.

14-pole, 3-phase Delta, Top-to-top. See Figs. 143, 144, 145, 146

Pole Number		I			II			III			IV			V		
Group Number	Fig.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Series	143	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16
2-parallel	144	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
7-parallel	145	" "	C "	" "	B "	B "	A "	A "	C "	C "	B "	B "	A "	A "	C "	C "
14-parallel	146	" B	C B	" A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A

		VI			VII			VIII			IX			X		
Group Number		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Series		19 14	15 17	18 16	19 20	21 17	18 39	22 20	21 23	24 39	22 25	26 23	24 27	28 25	26 29	30 27
2-parallel		" "	" C	" "	" B	" B	" A	" A	" 23	" C	" "	" "	" "	" "	" "	" "
7-parallel		B "	B 17	A "	A 20	C 17	C 39	B 20	B "	A 39	A "	C "	C "	B "	B "	A "
14-parallel		B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C

Pole Number		XI			XII			XIII			XIV		
Group Number		31	32	33	34	35	36	37	38	39	40	41	42
Series		28 31	32 29	30 33	34 31	32 35	36 33	34 37	C 35	36 38	B 37	B 3	A 38
2-parallel		" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
7-parallel		A "	C "	C "	B "	B "	A "	A "	" "	C "	" "	" "	" "
14-parallel		A B	C B	C A	B A	B C	A C	A B	" B	C A	" A	" C	" C

CHAPTER XXV

SIXTEEN-POLE, TWO- AND THREE-PHASE, STAR AND DELTA DIAGRAMS AND CONNECTING TABLES

Unlike the previous chapters this and the following chapters includes all the 2- and 3-phase, *T-T* connections for each pole in the one chapter. Only one diagram of each type is shown, that is, series, 2-phase *T-T*, series star *T-T*, and series delta *T-T*. For the other connections possible on sixteen poles, use Tables 36, 37 and 38 which show that a series, 2, 4, 8- and 16-parallel connection can be made.

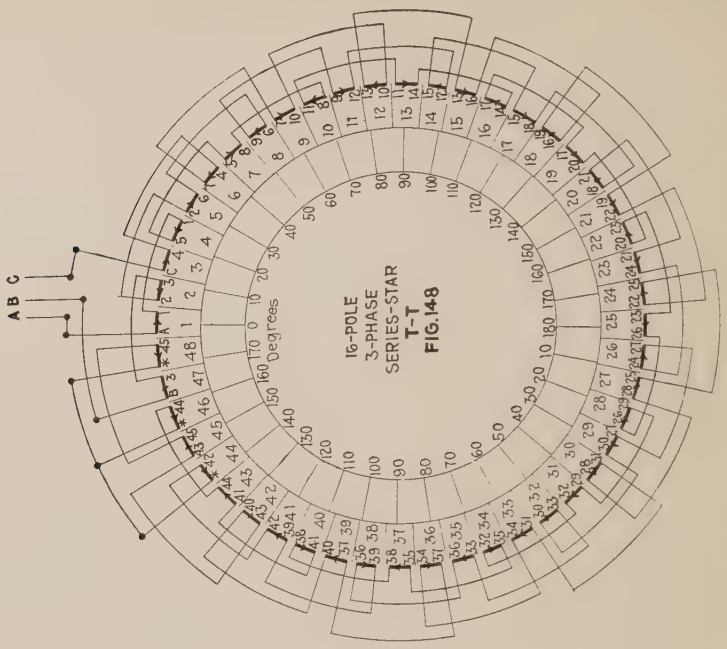
A motor can be connected directly from the tables by first connecting the coils in groups then tagging the top and bottom leads from the tables. See Chapter 6.

This chapter contains three diagrams, three group connecting tables and two coil grouping charts. Figs. 147 and 148 are laid out with the mechanical method of locating odd coil groupings, as explained in Chapter III. The coil grouping chart Y is to be used for both star and delta 3-phase windings. By using the tables, a star connection can be changed to delta or vice versa.

Chart R.—Unequal Coil Grouping for 16-pole, 2-phase, *T-T* Windings

16-pole, 2-phase, Top-to-top

Coils	Group Numbers																												No. large groups	No. small groups
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		
48	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	16	16
54	1	2	2	2	1	2–1	2	2	2	1	2	2	1	1	2	2	1	2	2	2	2–1	1	2	2	2	1	2	2	1	1	2	2	22	10
60	1	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	28	4
62	2–1	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2–1	2	2	2	2	2	2	30	2
72	3	3	2	2	2	2	2	2	3	3	2	2	2	2	2	2	3	3	2	2	2	2	2	2	3	3	2	2	2	2	2	2	8	24
80	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2		
84	2	3	3	3	2	2	3	3	3	2	3	3	2	2	3	3	2	3	3	3	2	2	3	3	3	2	3	3	2	2	3	3	20	12
86	2	3	3	3	2	3–1	3	3	3	2	3	3	2	2	3	3	3–1	3	3	3	2	2	3	3	3	2	3	3	2	2	3	3		
90	2	2	3	3	3	3	3	3	3–1	2	3	3	3	3	3	3	2	2	3	3	3	3	3	3	2	3–1	3	3	3	3	3	3	26	6
104	4	4	3	3	3	3	3	3	4	4	3	3	3	3	3	3	4	4	3	3	3	3	3	3	4	4	3	3	3	3	3	3		
108	4	5	5	5	4	4	5	5	5	4	5	5	4	4	5	5	4	5	5	5	4	4	5	5	5	4	5	5	4	4	5	5		
120	3	3	4	4	4	4	4	4	3	3	4	4	4	4	4	4	3	3	4	4	4	4	4	4	3	3	4	4	4	4	4	4	24	8
135	5	4	4	4	5–1	4	4	4	4	5	4	4	4	5–1	4	4	5	4	4	4	4	5–1	4	4	4	5	4	4	4	4	4	4	7	25
144	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4		
150	4	5	5	5	4	5–1	5	5	5	4	5	5	4	4	5	5	4	5	5	5	5–1	4	5	5	5	4	5	5	4	4	5	5	22	10
156	4	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5		
168	6	6	5	5	5	5	5	5	6	6	5	5	5	5	5	5	6	6	5	5	5	5	5	5	6	6	5	5	5	5	5	5		
180	5	6	6	6	5	5	6	6	6	5	6	6	5	5	6	6	5	6	6	6	5	5	6	6	6	5	6	6	5	5	6	6		
216	6	6	7	7	7	7	7	7	6	6	7	7	7	7	7	7	6	6	7	7	7	7	7	7	6	6	7	7	7	7	7	7		
240	7	7	8	8	7	7	8	8	7	7	8	8	7	7	8	8	7	7	8	8	7	7	8	8	7	7	8	8	7	7	8	8		


16-POLE
3-PHASE
SERIES-STAR
T-T
FIG.148
A B C
Degrees

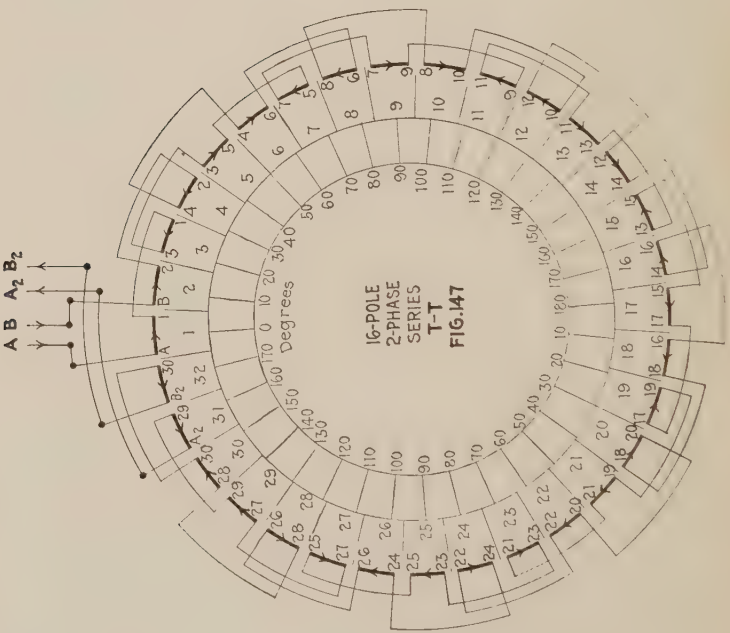

16-POLE
2-PHASE
SERIES
T-T
FIG.147
A B A2 B2
Degrees

TABLE 36.—CONNECTIONS FOR ENDS OF GROUPS FOR 16-POLE, 2-PHASE *T-T* WINDINGS

Connect together group ends having same number or letter. Letters indicate line leads.

16-pole, 2-phase, Top-to-top. See Fig. 147

Pole Number	I		II		III		IV		V		VI		VII		VIII	
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14
2-parallel	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "
4-parallel	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B "	" "	" "	" "	" "	" "	" "
8-parallel	" "	" "	A_2 "	B_2 "	A "	B "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B "	" "	" "
16-parallel	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" B_2	" B_2	" A	" B

Pole Number	IX		X		XI		XII		XIII		XIV		XV		XVI	
Group Number	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Series	15 17	16 18	19 17	20 18	19 21	20 22	23 21	24 22	23 25	24 26	27 25	28 26	27 29	28 30	A_2 29	B_2 30
2-parallel	A "	B "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
4-parallel	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B "	" "	" "	" "	" "	" "	" "
8-parallel	" "	" "	A_2 "	B_2 "	A "	B "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B "	" "	" "
16-parallel	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B

TABLE 37.—CONNECTIONS FOR ENDS OF GROUPS FOR 16-POLE, 3-PHASE STAR *T-T* WINDINGS

Connect together ends of groups that have same number or letter. Line leads are indicated by letters. Star connections are indicated by (*).

16-pole, 3-phase Star, Top-to-top. See Fig. 148

Pole Number	I			II			III			IV			V			VI		
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	A	1 2	3 C	4 5	1 2	6 7	4 5	8 9	6 7	10 11	8 9	12 13	10 11	14 15	12 13	16 17	14 15	18 19	16
2-parallel	"	" "	" "	" "	" "	" "	" "	" *	" "	" *	" B	" *	" A	" "	" C	" "	" *	" B	"
4-parallel	"	" *	" "	" *	" B	" *	" A	" "	" C	" "	" "	" *	" "	" *	" B	" *	" A	" *	" C
8-parallel	"	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C
16-parallel	"	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C

Pole Number	VII			VIII			IX			X			XI			XII		
Group Number	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Series	17	20 21	18 19	22 23	20 21	24 25	22 23	26 27	24 25	28 29	26 27	30 31	28 29	32 33	30 31	34 35	32 33	36 37	34
2-parallel	"	" *	" "	" *	" B	" *	" A	" "	" C	" "	" "	" *	" "	" *	" "	" *	" B	" *	"
4-parallel	"	" "	" C	" "	" "	" "	" "	" *	" "	" *	" B	" *	" A	" "	" C	" "	" "	" "	"
8-parallel	A	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" *	" "	"
16-parallel	"	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C

Pole Number	XIII			XIV			XV			XVI		
Group Number	37	38	39	40	41	42	43	44	45	46	47	48
Series	35	38 39	36 37	40 41	38 39	42 43	40 41	44 *	42 43	45 *	44 B	3 *	45
2-parallel	A	" "	" C	" "	" "	" "	" "	" "	" "	" "	" "	" "	"
4-parallel	"	" *	" C	" *	" B	" *	" A	" "	" C	" "	" "	" "	"
8-parallel	"	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C
16-parallel	"	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C

Chart S.—Unequal Coil Grouping for 16-pole, 3-phase *T-T* Star and Delta Windings

16-pole, 3-phase, Top-to-top. See Figs. 148 and 149

| Coils | Group Numbers | | |

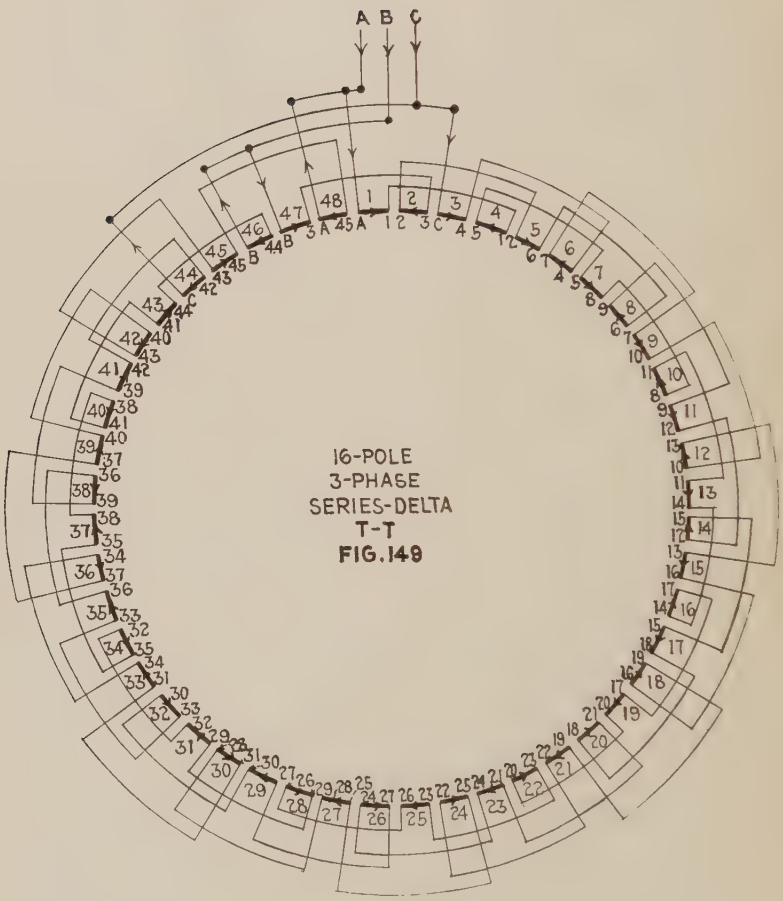

A B C
16-POLE
3-PHASE
SERIES-DELTA
T-T
FIG. 149

TABLE 38.—CONNECTIONS FOR ENDS OF GROUPS FOR 16-POLE, 3-PHASE, DELTA *T-T* WINDINGS

Connect together ends of groups having same numbers or letters. Letters indicate line leads.

16-pole, 3-phase Delta, Top-to-top. See Fig. 149

Pole Number	I			II			III			IV			V			VI		
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	A	1 2 3 C 4 5		1 2 6 7 4 5			8 9 6 7 10 11			8 9 12 13 10 11			14 15 12 13 16 17			14 15 18 19 16		
2-parallel	"	" " " " " "		" " " " " "			" " " " " "			" " " " " "			" " " " " "			" " " " " "		
4-parallel	"	" " " " " "		" " " " " "			" C " " " "			B " B " A "			A " " " C "			B " B " A "		
8-parallel	"	" C " " " B		" B " A " A			" " " C " C			" " " " " C			" C " " " B			" B " A "		
16-parallel	"	B " B " A		" A " C " C			" B " B " A			" A " C " C			" B " B " A			" A " C " C		

Pole Number	VII			VIII			IX			X			XI			XII		
Group Number	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Series	17	20 21 18 19 22		23 20 21 24 25 22			23 26 27 24 25 28			29 26 27 30 31 28			29 32 33 30 31 34			35 32 33 36 37 34		
2-parallel	"	" " C " " "		B " B " A "			A " " " C "			" " " " " "			" " C " " "			B " B " A "		
4-parallel	"	" " " " " "		" " " " " "			" " C " " "			B " B " A "			A " " " C "			" " " " " "		
8-parallel	A	" " " C " "		" " " " " "			" C " " " "			" " B " B "			" C " " " B			" B " A "		
16-parallel	"	B " B " A		" A " C " C			" B " B " A			" A " C " C			" B " B " A			" A " C " C		

Pole Number	XIII			XIV			XV			XVI		
Group Number	37	38	39	40	41	42	43	44	45	46	47	48
Series	35	38 39 36 37 40		41 38 39 42 43 40			41 44 C 42 43 45			B 44 B 3 A 45		
2-parallel	"	" " " " " "		" " " " " "			" " " " " "			" " " " " "		
4-parallel	A	" " " C " "		" " " " " "			A " " " C "			" " " " " "		
8-parallel	"	" C " " " "		B " B " A "			" " " " " "			" " " " " "		
16-parallel	"	B " B " A		" A " C " C			" B " B " A			" A " C " C		

CHAPTER XXVI

EIGHTEEN-POLE, TWO- AND THREE-PHASE, STAR AND DELTA DIAGRAMS AND CONNECTING TABLES

This chapter includes three diagrams, all series *T-T* connections, two group end connecting tables and two coil grouping charts. The Chart Z is for both the star and delta connections.

By using Tables 39, 40 and 41 and the methods and instructions outlined in Chapters 4 and 5, any of the following 18-pole, 2- and 3-phase connections can be made: Series, 2, 3, 6, 9 and 18-parallel or 6-parallel connections.

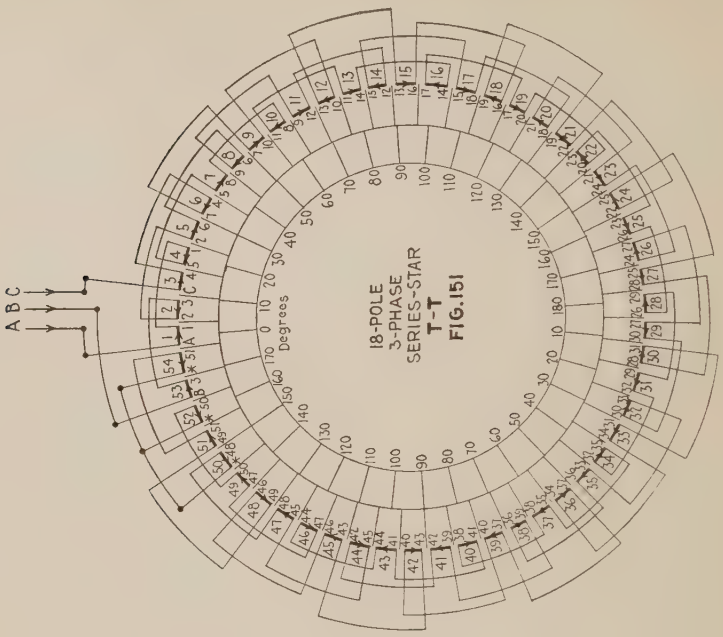
The tables can also be used to change from a star to a delta connection or vice versa, and to connect up a winding direct from the tables by tagging the group leads as explained in Chapter 6 on constructing a diagram from the tables.

CHART T.—UNEQUAL COIL GROUPING FOR 18-POLE, 2-PHASE *T-T* WINDINGS

18-pole, 2-phase, Top-to-top. See Fig. 150

Groups	Group Numbers																																No. large groups	No. small groups
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
48	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	12	24
54	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	18	18
60	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	24	12
62	1	2	2	1	2	2	2–1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	2–1	2	2	1	2	2	1	2	2	26	10
80	3	3	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	8	28
84	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2		
86	3	2	2	3	2	3–1	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	3–1	3	2	2	3	2	2	3	2	2	3	2	2	14	22
90	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2		
96	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3		
104	2	3[k]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3[k]	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	34	2
120	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3		
128	3	3	4	4	4	4	3	3	3	3	4	4	3	3	4	4	4	4	3	3	4	4	4	4	3	3	3	3	4	4	3	3	4	4	4	4	20	16
135	3	4[k]	4	4	4	4	4	4	3	3	3	4–1	4	4	4	4	4	4	4[k]	3	4	4	4	4	4	4	3	3	3	3	4	4	4	4	4	4	27	9
150	5[k]	4	4	4	4	4	4	5	4	4	4	4	5	4	4	4	4	4	4	5[k]	4	4	4	4	5	4	4	4	4	4	4	5	4	4	4	4	6	30
156	5	4	4	5	4	4	5	4	4	5	4	4	5	4	4	5	4	4	5	4	4	5	4	4	5	4	4	5	4	4	5	4	4	5	4	4		
150	5	5	4	4	4	4	5	5	5	5	4	4	5	5	4	4	4	4	5	5	4	4	4	4	5	5	5	5	4	4	5	5	4	4	4	4	16	20
168	4	5	5	4	5	5	4	5	5	4	5	5	4	5	5	4	5	5	4	5	5	4	5	5	4	5	5	4	5	5	4	5	5	4	5	5		
240	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7		

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding (see pages 8–9).


A B C
18-POLE
3-PHASE
SERIES-STAR
T-T
FIG.151
Degrees

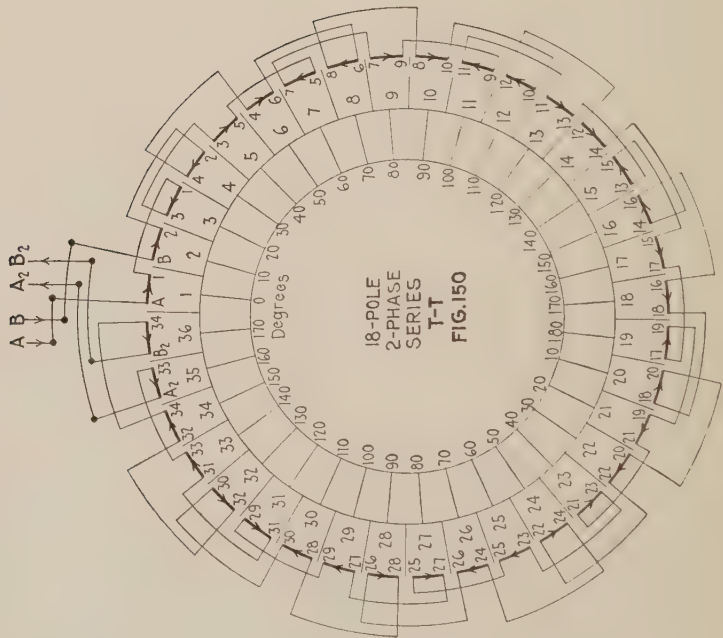

A B A2 B2
18-POLE
2-PHASE
SERIES
T-T
FIG.150
Degrees

TABLE 39.—CONNECTIONS FOR ENDS OF GROUPS FOR 18-POLE, 2-PHASE *T-T* WINDINGS

Connect together group ends having same number or letter. Letters indicate line leads.

18-pole, 2-phase, Top-to-top. See Fig. 150

Pole Number	I		II		III		IV		V		VI	
Group Number	1	2	3	4	5	6	7	8	9	10	11	12
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10
2-parallel	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
3-parallel	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "
6-parallel	" "	" "	" "	" "	" A_2	" B_2	" A	" B	" "	" "	" "	" "
9-parallel	" "	" "	A_2 "	B_2 "	A 5	B 6	A_2 5	B_2 6	A "	B "	" "	" "
18-parallel	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B

Pole Number	VII		VIII		IX		X		XI		XII	
Group Number	13	14	15	16	17	18	19	20	21	22	23	24
Series	11 13	12 14	15 13	16 14	15 17	16 18	19 17	20 18	19 21	20 22	23 21	24 22
2-parallel	" "	" "	" "	" "	" A_2	" B_2	" A	" B	" "	" "	" "	" "
3-parallel	A "	B "	" "	" "	" 17	" 18	" 17	" 18	" "	" "	A_2 "	B_2 "
6-parallel	" "	" "	" "	" "	" A_2	" B_2	" A	" B	" "	" "	" "	" "
9-parallel	" "	" "	A_2 "	B_2 "	A 17	B 18	A_2 17	B_2 18	A "	B "	" "	" "
18-parallel	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B

Pole Number	XIII		XIV		XV		XVI		XVII		XVIII	
Group Number	25	26	27	28	29	30	31	32	33	34	35	36
Series	23 25	24 26	27 25	28 26	27 29	28 30	31 29	32 30	31 33	32 34	A_2 33	B_2 34
2-parallel	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
3-parallel	A "	B "	" "	" "	" "	" "	" "	" "	" "	" "	" "	"
6-parallel	" "	" "	" "	" "	" A_2	" B_2	" A	" B	" "	" "	" "	" "
9-parallel	" "	" "	A_2 "	B_2 "	A 29	B 30	A_2 29	B_2 30	A "	B "	" "	" "
18-parallel	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B

TABLE 40.—CONNECTIONS FOR ENDS OF GROUPS OF 18-POLE, 3-PHASE, STAR *T-T* WINDINGS

Connect ends of groups together that have same numbers or letters. Letters indicate line leads. (*) indicates a star connection.

18-pole, 3-phase Star, Top-to-top. See Fig. 151

Pole Number...	I			II			III			IV			V			VI			VII			VIII			IX		
Group Number..	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Series.....	A	1 2	3 C	4 5	1 2	6 7	4 5	8 9	6 7	10 11	8 9	12 13	10 11	14 15	12 13	16 17	14 15	18 19	16 17	20 21	18 19	22 23	20 21	24 25	22 23	26 27	24 25	28
2-parallel.....	"	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	* "	B "	*
3-parallel.....	"	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	* "	* "	* "	* "	B "	* "	A "	" "	C "	" "	" "	" 24	" "	" 26	" 24	" 28
6-parallel.....		" "	" "	" "	" "	" "	" *	" B	" *	" A	" B	" C	" C	" "	" "	" C	" "	" "	" "	" "	" "	" "	" *	" B	" "	" *	" B	" *
9-parallel.....	"	" *	" "	" *	" B	6 *	" A	8 *	6 C	10 *	8 B	' *	10 A	" "	" C	" "	" "	" "	" *	" B	" *	" A	" B	24 *	" A	26 *	24 C	28
18-parallel.....	"	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C "	* "	B "	*

Pole Number...	X			XI			XII			XIII			XIV			XV			XVI			XVII			XVIII		
Group Number..	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Series.....	29 26	27 30	31 28	29 32	33 30	31 34	35 32	33 36	37 34	35 38	39 36	37 40	41 38	39 42	43 40	41 44	45 42	43 46	47 44	45 48	49 46	47 50	* 48	49 51	* 50	B 3	* 51
2-parallel.....	" A	" "	" C	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	"
3-parallel.....	" 26	" "	" 28	" "	* "	" "	* "	B "	* "	A "	" "	C "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	"
6-parallel.....	" A	" "	" C	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" *	" B	" *	" A	" "	" C	" "	" "	" "	" "	" "	" "	"
9-parallel.....	* 26	B "	* 28	A "	" "	C "	" "	" "	" "	" "	* "	" "	* "	B 42	* "	A 44	* 42	C 46	* 44	B "	* 46	A "	" "	C "	" "	" "	" "	"
18-parallel.....	" A	" *	" C	" *	" B	" *	" A	" *	" C	" *	" B	" *	" A	" *	" C	" *	" B	" *	" A	" *	" C	" *	" B	" *	" A	" *	" C

Chart U.—Unequal Coil Grouping for 18-pole, 3-phase *T-T* Windings

18-pole, 3-phase, Top-to-top, Star and Delta. See Figs. 150 and 151

Coils	Group Numbers																									No. large groups	No. small groups
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		
60	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	6	48
62	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	2–1	1	1	1	1	8	46
72	2	1	2	1	2	1	1	1	1	2	1	2	1	2	1	1	1	1	2	1	2	1	2	1	1	1	1	18	36
80	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	26	28
84	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	2[k]	2	1	2	1	2	1	2	1	2	1	30	24
86	2–1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	2[k]	2	1	2	2–1	2	1	2	1	2	1	32	22
90	1	2	1	2	1	2	2	2	2	1	2	1	2	1	2	2	2	2	1	2	1	2	1	2	2	2	2	36	18
96	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	42	12
104	1	2	2	2	2	2	2	2	2–1	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	50	4
120	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	2	2	2	12	42
128	3	2	3	2	3	2	2	2	2	3	2	3	2	3	2	2	2	2	3	2	3	2	3	2	2	3–1	2	20	34
135	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	27	27
144	2	3	2	3	2	3	3	3	3	2	3	2	3	2	3	3	3	3	2	3	2	3	2	3	3	3	3	36	18
150	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	3	3	3		
156	2	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	48	6
160	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3–1	3	3	3	3	3	3	3	52	2
168	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3		
180	4	3	4	3	4	3	3	3	3	4	3	4	3	4	3	3	3	3	4	3	4	3	4	3	3	3	3		
240	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	4	4	5	4	5	4	5	4	5	4	5	24	30

Coils	Group Numbers																									No. large groups	No. small groups
	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54		
60	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	6	48
62	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2–1	1	1	1	8	46
72	2	1	2	1	2	1	1	1	1	2	1	2	1	2	1	1	1	1	2	1	2	1	2	1	1	1	1	18	36
80	1	2	1	2	1	2–1	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2–1	1	2	1	2	1	26	28
84	2	1	2	1	2	2[k]	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	2[k]	2	1	2	1	2	30	24
86	2	1	2	1	2	2[k]	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	2[k]	2	1	2	1	2	32	22
90	1	2	1	2	1	2	2	2	2	1	2	1	2	1	2	2	2	2	1	2	1	2	1	2	2	2	2	36	18
96	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	42	12
104	1	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2–1	2	2	2	2	2	2	2	2	2	2	50	4
120	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	2	2	2	12	42
128	3	2	3	2	3	2	2	2	2	3	2	3	2	3	2	2	3–1	2	3	2	3	2	3	2	2	2	2	20	34
135	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	27	27
144	2	3	2	3	2	3	3	3	3	2	3	2	3	2	3	3	3	3	2	3	2	3	2	3	3	3	3	36	18
150	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	3	3	3		
156	2	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	48	6
160	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	52	2
168	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3		
180	4	3	4	3	4	3	3	3	3	4	3	4	3	4	3	3	3	3	4	3	4	3	4	3	3	3	3		
240	4	5	4	5	4	4	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	4	4	5	4	5	4	24	30

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding (see pages 8–9).

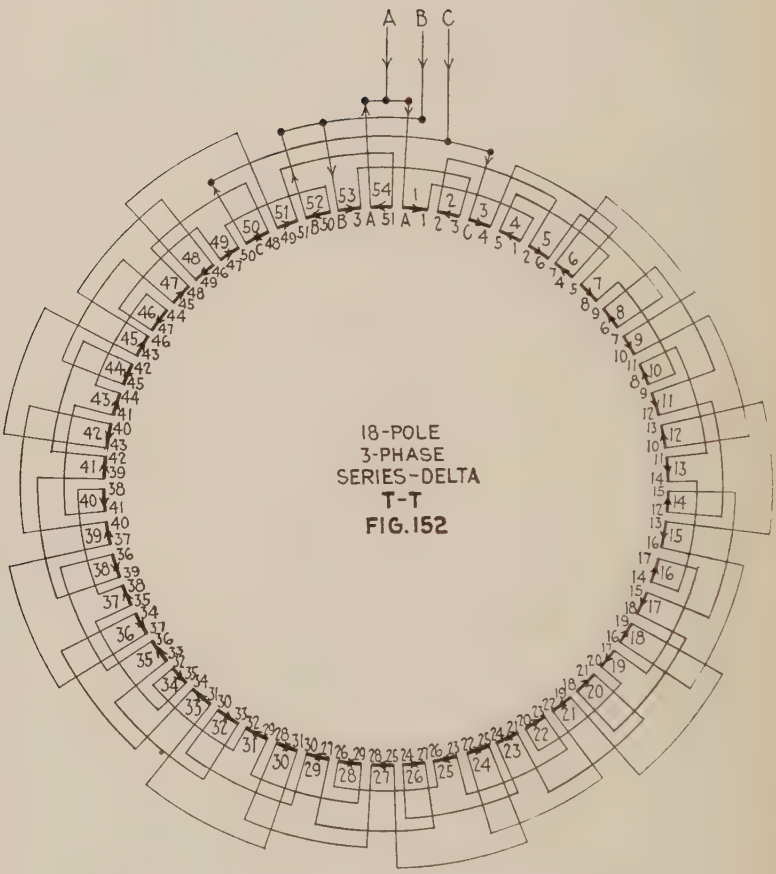

A B C
18-POLE
3-PHASE
SERIES-DELTA
T-T
FIG. 152

TABLE 41.—CONNECTIONS FOR ENDS OF GROUPS OF 18-POLE, 3-PHASE, DELTA *T-T* WINDINGS

Connect ends of groups together that have same numbers or letters. Letters indicate line leads.

18-pole, 3-phase Delta, Top-to-top. See Fig. 152

Pole Number	I			II			III			IV			V			VI			VII			VIII			IX		
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Series	A	1	2	3	C	4	5	1	2	6	7	4	5	8	9	6	7	10	11	8	9	12	13	10	11	14	15	12	13	16	17	14	15	18	19	16	17	20	21	18	19	22	23	20	21	24	25	22	23	26	27	24	25	28
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	C	"	"	"	B	"	B	"	A
3-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	B	"	B	"	A	"	A	"	"	"	C	"	"	"	"	"	24	"	"	"	26	"	24	"	28
6-parallel	"	"	"	"	"	"	"	"	C	"	"	"	B	"	B	"	B	"	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	C	"	"	"	"	B	"	B	"	A
9-parallel	"	"	C	"	"	"	B	"	B	6	A	"	A	8	C	6	C	10	B	8	B	"	A	10	A	"	"	"	C	"	"	"	"	"	"	"	"	"	C	"	"	"	B	"	B	24	A	"	A	26	C	24	C	28
18-parallel	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	A	"	C	"	C	"	A	"	B	"	B	"	A

Pole Number	X			XI			XII			XIII			XIV			XV			XVI			XVII			XVIII		
Group Number	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Series	29	26	27	30	31	28	29	32	33	30	31	34	35	32	33	36	37	34	35	38	39	36	37	40	41	38	39	42	43	40	41	44	45	42	43	46	47	44	45	48	49	46	47	50	C	48	49	51	B	50	B	3	A	51
2-parallel	"	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
3-parallel	"	26	"	"	"	28	"	"	C	"	"	"	B	"	B	"	A	"	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
6-parallel	"	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
9-parallel	B	26	B	"	A	28	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	C	"	"	"	"	"	B	"	B	42	A	"	A	44	C	42	C	46	B	44	B	"	A	46	A	"	"	"	C	"	"	"	"	"
18-parallel	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C

CHAPTER XXVII

TWENTY-POLE, TWO- AND THREE-PHASE, STAR AND DELTA DIAGRAMS AND CONNECTING TABLES

The diagrams and tables of this chapter, including the coil grouping charts, will enable any of the following connections to be made: Series, 2, 4, 5, 10 and 20-parallel or six possible connections of each phase and type. Tables 42, 43 and 44 can be used to construct the above diagrams or the winding can be connected direct from the tables.

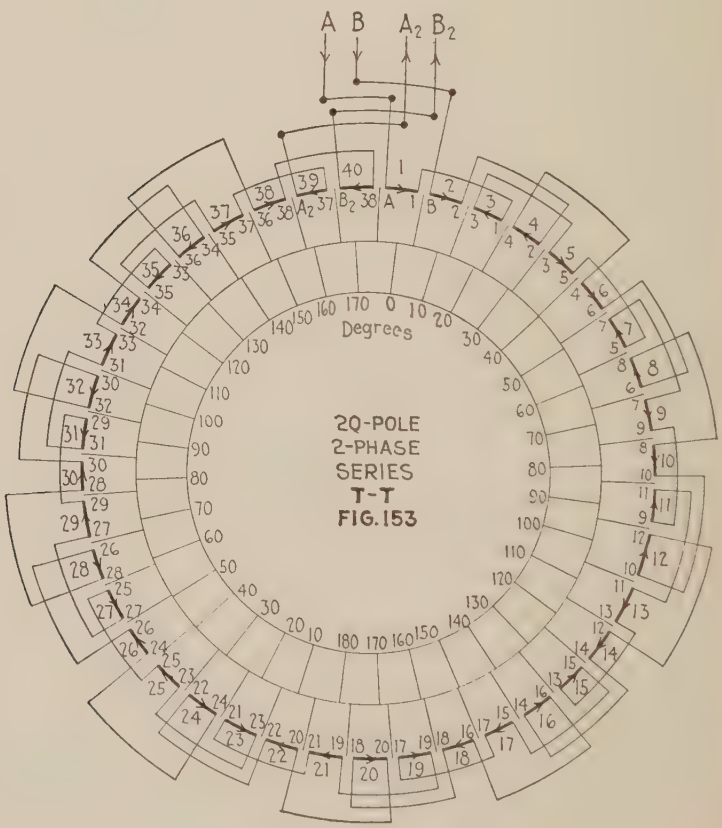


TABLE 42.—CONNECTIONS FOR ENDS OF GROUPS FOR 20-POLE, 2-PHASE *T-T* WINDINGS

Connect together group ends having same number or letter. Letters indicate line leads.

20-pole, 2-phase, Top-to-top. See Fig. 153

Pole Number	I		II		III		IV		V		VI		VII		VIII		IX		X	
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14	15 17	16 18	19 17	20 18
2-parallel	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "
4-parallel	" "	" "	" "	" "	" "	" "	" "	" "	" A_2	" B_2	" A	" B	" "	" "	" "	" "	" "	" "	" "	" "
5-parallel	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "	A 9	B 10	" 9	" 10	" "	" "	A_2 "	B_2 "	A "	B "	19 "	20 "
10-parallel	" "	" "	" "	" "	A_2 "	B_2 "	A "	B "	" "	" "	A_2 "	B_2 "	A "	B "	" "	" "	" "	" "	A_2 "	B_2 "
20-parallel	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B

Pole Number	XI		XII		XIII		XIV		XV		XVI		XVII		XVIII		XIX		XX	
Group Number	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Series	19 21	20 22	23 21	24 22	23 25	24 26	27 25	28 26	27 29	28 30	31 29	32 30	31 33	32 34	35 33	36 34	35 37	36 38	A_2 37	B_2 38
2-parallel	A "	B "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
4-parallel	" "	" "	" "	" "	" "	" "	" "	" "	" A_2	" B_2	" A	" B	" "	" "	" "	" "	" "	" "	" "	" "
5-parallel	19 "	20 "	A_2 "	B_2 "	A "	B "	" "	" "	" 29	" 30	A_2 29	B_2 30	A "	B "	" "	" "	" "	" "	" "	" "
10-parallel	A "	B "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B "	" "	" "
20-parallel	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B

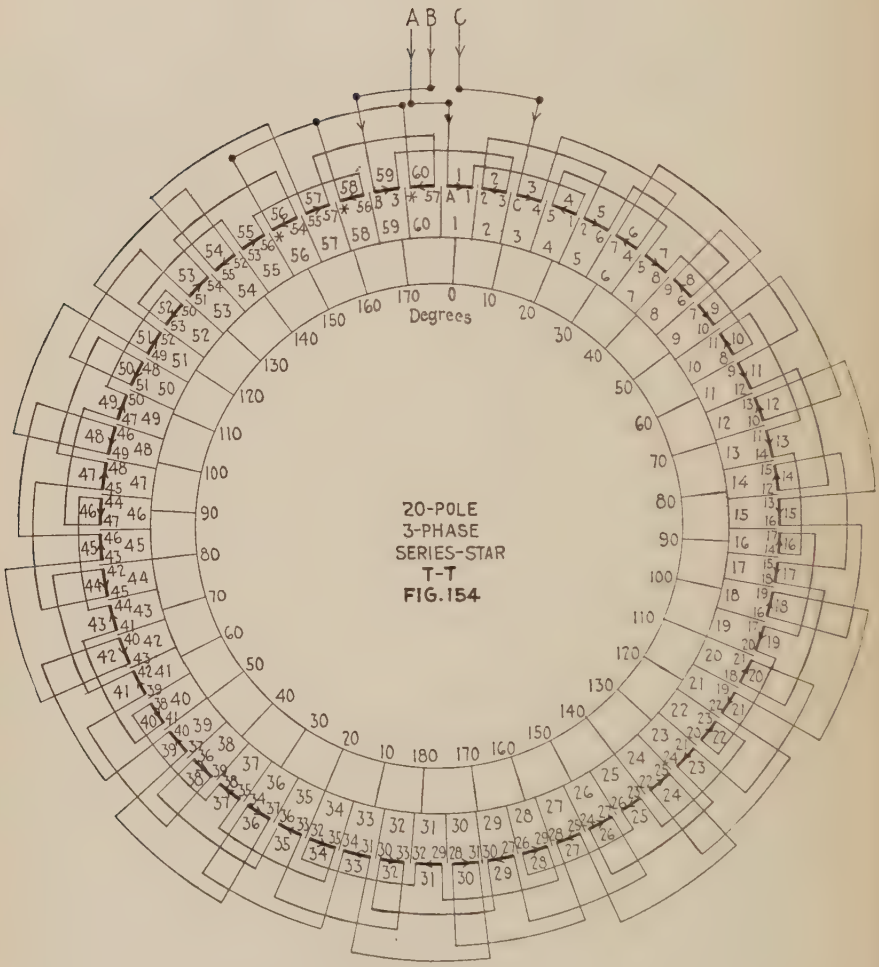

A B C
Degrees
20-POLE
3-PHASE
SERIES-STAR
T-T
FIG. 154

TABLE 43.—CONNECTIONS FOR ENDS OF GROUPS FOR 20-POLE, 3-PHASE, STAR *T-T* WINDINGS

Connect together ends of groups having same numbers or letters. Letters indicate line leads. Star connection is indicated by (*).

20-pole, 3-phase Star, Top-to-top. See Fig. 154

Pole Number	I			II			III			IV			V			VI			VII			VIII			IX			X		
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Series	A	1	2	3	C	4	5	1	2	6	7	4	5	8	9	6	7	10	11	8	9	12	13	10	11	14	15	12	13	16
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	"	"	"	"	"	"	"	"	"	"	"	*	"	"	B	"	*	"	A	"	"	"	C	"	"	"	"	"	"	"	"	"
5-parallel	"	"	"	"	"	"	"	*	"	"	*	"	B	12	*	"	A	14	"	12	C	16	"	"	"	"	"	"	"	"	"	"
10-parallel	"	"	*	"	"	*	"	B	"	*	"	A	"	"	*	"	"	C	"	"	B	"	*	"	A	"	"	"	"	"	"	"
20-parallel	"	*	"	B	"	*	"	A	"	*	"	B	"	*	"	A	"	*	"	C	"	*	"	B	"	*	"	C	"	*	"	B

Pole Number	XI			XII			XIII			XIV			XV			XVI			XVII			XVIII			XIX			XX		
Group Number	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Series	29	32	33	30	31	34	35	32	33	36	37	34	35	38	39	36	37	40	41	38	39	42	43	40	41	44	45	42	43	46
2-parallel	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	"	"	"	"	"	"	"	"	"	"	"	*	"	"	B	"	*	"	A	"	"	"	C	"	"	"	"	"	"	"	"	"
5-parallel	29	"	*	"	31	"	*	"	B	"	*	"	A	"	"	C	"	"	*	"	"	42	"	"	"	44	*	42	"	"	46
10-parallel	A	"	"	"	C	"	"	*	"	"	*	"	B	"	*	"	"	C	"	"	A	"	*	"	"	"	"	"	"	"	"	"
20-parallel	"	*	"	B	"	*	"	A	"	*	"	B	"	*	"	A	"	*	"	C	"	*	"	B	"	*	"	C	"	*	"	B

Pole Number	XI			XII			XIII			XIV			XV			XVI			XVII			XVIII			XIX			XX		
Group Number	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Series	29	32	33	30	31	34	35	32	33	36	37	34	35	38	39	36	37	40	41	38	39	42	43	40	41	44	45	42	43	46
2-parallel	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	"	"	"	"	"	"	"	"	"	"	"	*	"	"	B	"	*	"	A	"	"	"	C	"	"	"	"	"	"	"	"	"
5-parallel	29	"	*	"	31	"	*	"	B	"	*	"	A	"	"	C	"	"	*	"	"	42	"	"	"	44	*	42	"	"	46
10-parallel	A	"	"	"	C	"	"	*	"	"	*	"	B	"	*	"	"	C	"	"	A	"	*	"	"	"	"	"	"	"	"	"
20-parallel	"	*	"	B	"	*	"	A	"	*	"	B	"	*	"	A	"	*	"	C	"	*	"	B	"	*	"	C	"	*	"	B

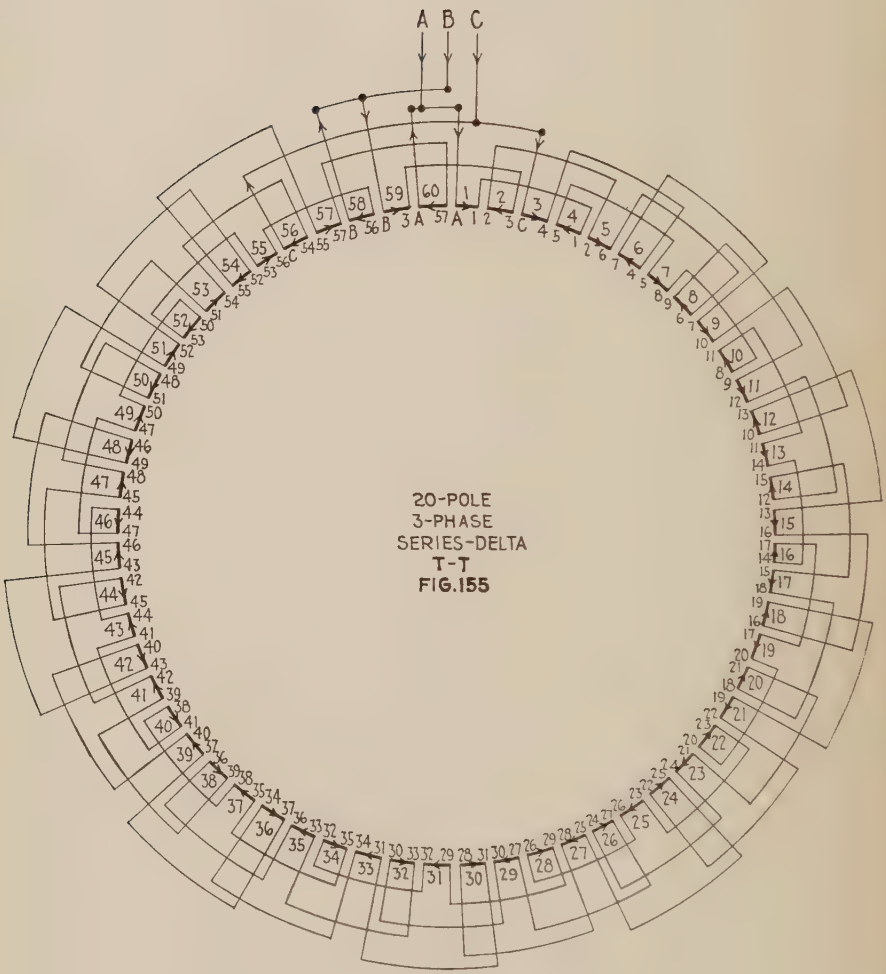

A B C
20-POLE
3-PHASE
SERIES-DELTA
T-T
FIG.155

TABLE 44.—CONNECTIONS FOR ENDS OF GROUPS OF 20-POLE, 3-PHASE, DELTA *T-T* WINDINGS

Connect together ends of groups having same numbers or letters. Letters indicate line leads.

20-pole, 3-phase Delta, Top-to-top. See Fig. 155

Pole Number	I			II			III			IV			V			VI			VII			VIII			IX			X		
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Series	A	1	2	3	C	4	5	1	2	6	7	4	5	8	9	6	7	10	11	8	9	12	13	10	11	14	15	12	13	16
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	"	"	"	"	"	"	"	"	"	"	"	C	"	"	B	"	B	"	A	"	A	"	"	"	C	"	"	"	"	"	"	"
5-parallel	"	"	"	"	"	"	"	"	C	"	"	"	B	"	B	12	A	"	A	14	"	12	C	16	"	14	"	"	"	16	"	"
10-parallel	"	"	C	"	"	B	"	B	"	A	"	A	"	"	"	C	"	"	"	"	B	"	B	"	A	"	A	"	"	"	C	"
20-parallel	"	B	"	B	"	A	"	A	"	C	"	C	B	"	B	"	A	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"

Pole Number	XI			XII			XIII			XIV			XV			XVI			XVII			XVIII			XIX			XX		
Group Number	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Series	29	32	33	30	31	34	35	32	33	36	37	34	35	38	39	36	37	40	41	38	39	42	43	40	41	44	45	42	43	46
2-parallel	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	"	"	"	"	"	"	"	"	"	"	"	C	"	"	B	"	B	"	A	"	A	"	"	"	C	"	"	"	"	"	"	"
5-parallel	29	"	C	"	31	"	B	"	B	"	A	"	A	"	"	"	"	C	"	"	"	42	"	"	"	"	44	C	42	"	46
10-parallel	A	"	"	"	C	"	"	"	C	"	"	"	B	"	B	"	A	"	A	"	"	"	"	"	"	"	"	"	"	"	"	"
20-parallel	"	B	"	B	"	A	"	A	"	C	"	C	B	"	B	"	A	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"

Pole Number	XI			XII			XIII			XIV			XV			XVI			XVII			XVIII			XIX			XX		
Group Number	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Series	44	45	42	43	46	47	44	45	48	49	46	47	50	51	48	49	52	53	50	51	54	55	52	53	56	C	54	55	57	B
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	"	"	C	"	"	"	"	"	"	"	"	"	"	B	"	B	"	A	"	A	"	"	"	"	"	"	"	"	"	"	"	"
5-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
10-parallel	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"
20-parallel	"	B	"	B	"	A	"	A	"	C	"	C	B	"	B	"	A	"	A	"	C	"	C	"	C	"	B	"	B	"	A	"

Pole Number	XI			XII			XIII			XIV			XV			XVI			XVII			XVIII			XIX			XX		
Group Number	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Series	B	56	B	3	A	57																								
2-parallel	"	"	"	"	"	"																								
4-parallel	"	"	"	"	"	"																								
5-parallel	"	"	"	"	"	"																								
10-parallel	"	"	"	"	"	"																								
20-parallel	"	A	"	C	"	C																								

CHART V.—UNEQUAL COIL GROUPING FOR 20-POLE, 2-PHASE, *T-T* WINDINGS
20-pole, 2-phase, Top-to-top. See Fig. 153

Coils	Group Numbers																		No. large groups	No. small groups
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
48	2	2	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	8	32
54	2[k]	2	1	1	1	1	2	2	1	1	2	1	1	1	2	2	1	1	1	1	14	26
60	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	20	20
62	2	2	1	1	2	2	2–1	1	2	2	1	1	2	2	1	1	2	2	1	1	22	18
72	1	1	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2	2	32	8
84	3	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	4	36
86	3	2	2	2	2	2	3–1	2	2	2	2	3	2	2	2	2	2	2	2	2	6	34
90	3[k]	3	2	2	2	2	2	2	3	3	2	2	2	2	2	2	3	3[k]	2	2	10	30
96	3	3	3	3	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	16	24
104	2	2	2	2	3	3	3	3	3	3	2	2	2	2	3	3	3	3	3	3	24	16
108	2	2	3	3	3	2	3	3	3	3	2	2	3	3	2	3	3	3	3	3	28	12
128	4	4	3	3	3	3	3	3	3	3	4	4	3	3	3	3	3	3	3	3		
135	4[k]	4	3	3	4–1	3	4	4	3	3	4	3	3	3	4	4	3	3	3	3	10	25
144	3	3	3	3	4	4	4	4	4	4	3	3	3	3	4	4	4	4	4	4		
150	3	3	4	4	4	4	4	4	3	3	4	4	4	4	4	4	3	3	4	4	30	10
156	3	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	36	4
168	5	5	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	4	4		
180	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4		
216	6	6	6	6	5	5	5	5	5	5	6	6	6	6	5	5	5	5	5	5		

Coils	Group Numbers																		No. large groups	No. small groups
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		
48	2	2	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	8	32
54	2	2[k]	1	1	1	1	2	2	1	1	1	2	1	1	2	2	1	1	2	1	14	26
60	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	20	20
62	2	2	1	2–1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	22	18
72	1	1	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2	2	32	8
84	3	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	4	36
86	3	2	2	2	2	2	2	3–1	2	2	2	3	2	2	2	2	2	2	2	2	6	34
90	2	2	2	2	3	3	2	2	2	2	2	2	3	3	2	2	2	2	2	2	10	30
96	3	3	3	3	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	16	24
104	2	2	2	2	3	3	3	3	3	3	2	2	2	2	3	3	3	3	3	3	24	16
108	2	2	3	3	3	2	3	3	3	3	2	2	3	3	2	3	3	3	3	3	28	12
128	4	4	3	3	3	3	3	3	3	3	4	4	3	3	3	3	3	3	3	3		
135	4	4[k]	3	3	3	3	4	4	3	3	3	4	3	3	4	4	3	3	3	3	15	25
144	3	3	3	3	4	4	4	4	4	4	3	3	3	3	4	4	4	4	4	4		
150	4	4[k]	4	4	3	3	4	4	4	4	4	4	3	3	4	4	4[k]	4	4	4	30	10
156	3	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	36	4
168	5	5	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	4	4	4		
180	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4		
216	6	6	6	6	5	5	5	5	5	5	6	6	6	6	5	5	5	5	5	5		

[k] A coil is killed in each group where this symbol appears, provided it appears also in the Main Table for this winding (see pages 8–9).

Chart W.—Unequal Coil Grouping for 20-pole, 3-phase, Star and Delta Windings

20-pole, 3-phase, Top-to-top. See Figs. 154 and 155

Coils	Group Numbers																												No. large groups	No. small groups
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
62	1	1	1	1	2–1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
72	2	1	1	1	1	2	1	1	1	1	2	1	1	1	1	2	1	1	1	1	2	1	1	1	1	2	1	1	1	1	12	48
80	2	1	2	1	2	1	1	1	1	1	2	1	2	1	2	1	1	1	1	1	2	1	2	1	2	1	1	2–1	1	1	20	40
84	2	2	2	1	1	1	2	2	2	1	1	1	1	1	1	2	2	2	1	1	1	2	2	2	1	1	1	1	1	1	25	36
86	2	2	2	1	1	1	2	2	2	1	1	2–1	1	1	1	2	2	2	1	1	1	2	2	2	1	1	1	1	1	1	26	34
90	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	30	30
96	1	1	1	2	2	2	1	1	1	2	2	2	2	2	2	1	1	1	2	2	2	1	1	1	2	2	2	2	2	2	36	24
104	2–1	2	1	2	1	2	2	2	2	2	1	2	1	2	1	2	2	2	2	2	1	2	1	2	2–1	2	2	2	2	2	44	16
108	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	48	12
128	3	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	3–1	2	2	2	3	2	2	2	2	2	2	2	2	2	8	52
135	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	15	45
144	3	3	3	2	2	2	3	3	3	2	2	2	2	2	2	3	3	3	2	2	2	3	3	3	2	2	2	2	2	2		
150	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2		
156	2	2	2	3	3	3	2	2	2	3	3	3	3	3	3	2	2	2	3	3	3	2	2	2	3	3	3	3	3	3		
160	2	2	2	3	3	3	2	2	2	3	3	3	3	3	3	2	2	3–1	3	3	3	2	2	2	3	3	3	3	3	3	40	20
168	2	3	3	3	3	2	3	3	3	3	2	3	3	3	3	2	3	3	3	3	3	3	3	3	3	2	3	3	3	3		
216	3	3	3	4	4	4	3	3	3	4	4	4	4	4	4	3	3	3	4	4	4	3	3	3	4	4	4	4	4	4		

Coils	Group Numbers																												No. large groups	No. small groups
	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		
62	1	1	1	2–1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
72	2	1	1	1	1	2	1	1	1	1	2	1	1	1	1	2	1	1	1	1	2	1	1	1	1	2	1	1	1	1	12	48
80	2	1	2	1	2	1	1	2–1	1	1	2	1	2	1	2	1	1	1	1	1	2	1	2	1	2	1	1	1	1	1	20	40
84	2	2	2	1	1	1	2	2	2	1	1	1	1	1	1	2	2	2	1	1	1	2	2	2	1	1	1	1	1	1	24	36
86	2	2	2	1	2–1	1	2	2	2	1	1	1	1	1	1	2	2	2	1	1	1	2	2	2	1	1	1	1	1	1	26	34
90	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	30	30
96	1	1	1	2	2	2	1	1	1	2	2	2	2	2	2	1	1	1	2	2	2	1	1	1	2	2	2	2	2	2	36	24
104	1	2	1	2	1	2	2	2	2	2	1	2	1	2	1	2	2	2	2	2	1	2	1	2	1	2	2	2	2	2	44	16
108	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	48	12
128	3	2	2	2	2	2	2	2	2	2	3	2	2	2	3–1	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	8	52
135	2	2	3	2	2	2	3	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	3	2	3	2	2	2	2	2	15	45
144	3	3	3	2	2	2	3	3	3	2	2	2	2	2	2	3	3	3	2	2	2	3	3	3	2	2	2	2	2	2		
150	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2		
156	2	2	2	3	3	3	2	2	2	3	3	3	3	3	3	2	2	2	3	3	3	2	2	2	3	3	3	3	3	3		
160	2	2	2	3	3	3	2	2	2	3	3	3	3	3	3	2	2	3–1	3	3	3	2	2	2	3	3	3	3	3	3	40	20
168	2	3	3	3	3	2	3	3	3	3	3	2	3	3	3	2	3	3	3	3	3	3	3	3	3	2	3	3	3	3		
216	3	3	3	4	4	4	3	3	3	4	4	4	4	4	4	3	3	3	4	4	4	3	3	3	4	4	4	4	4	4		

CHAPTER XXVIII

TWENTY-TWO POLE, TWO- AND THREE-PHASE, STAR AND DELTA DIAGRAMS AND CONNECTING TABLES

On any 22-pole winding there are only four connections possible. These are series, 2, 11 and 22-parallel. The Tables 45, 46 and 47 will enable the desired connection to be made either by constructing a diagram from the table or using the table to connect up the winding direct. The coil grouping Chart U is to be used for both the star and delta connections.

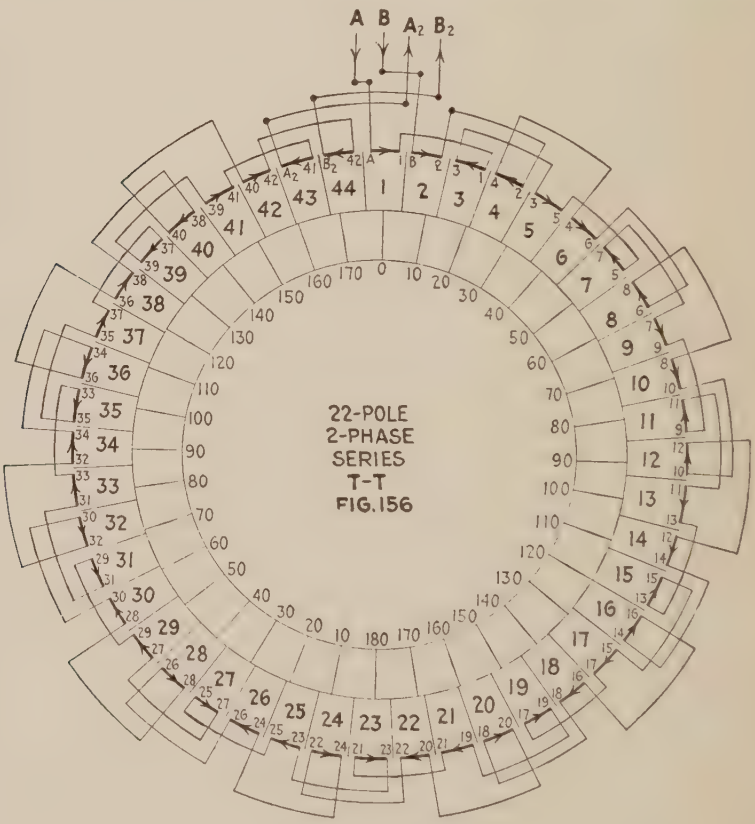


TABLE 45.—CONNECTIONS FOR ENDS OF GROUPS FOR 22-POLE, 2-PHASE *T-T* WINDINGS

Connect together group ends having same number or letter. Letters indicate line leads.

22-pole, 2-phase, Top-to-top. See Fig. 156

Pole Number	I		II		III		IV		V		VI		VII		VIII		IX		X		XI	
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Series	A	1 B	2 3	1 4	2 3	5 4	6 7	5 8	6 7	9 8	10 11	9 12	10 11	13 12	14 15	13 16	14 15	17 16	18 19	17 20	18 19	21 20	22
2-parallel	"	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" A_2	" B_2
11-parallel	"	" "	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	21 B	22
22-parallel	"	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2

Pole Number	XII		XIII		XIV		XV		XVI		XVII		XVIII		XIX		XX		XXI		XXII	
Group Number	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
Series	23	21 24	22 23	25 24	26 27	25 28	26 27	29 28	30 31	29 32	30 31	33 32	34 35	33 36	34 35	37 36	38 39	37 40	38 39	41 40	42 A_2	41 B_2	42
2-parallel	"	A "	B "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
11-parallel	A_2	21 B_2	22 A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" A_2	" B_2	" A	" B	" "	" "	" "
22-parallel	"	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B

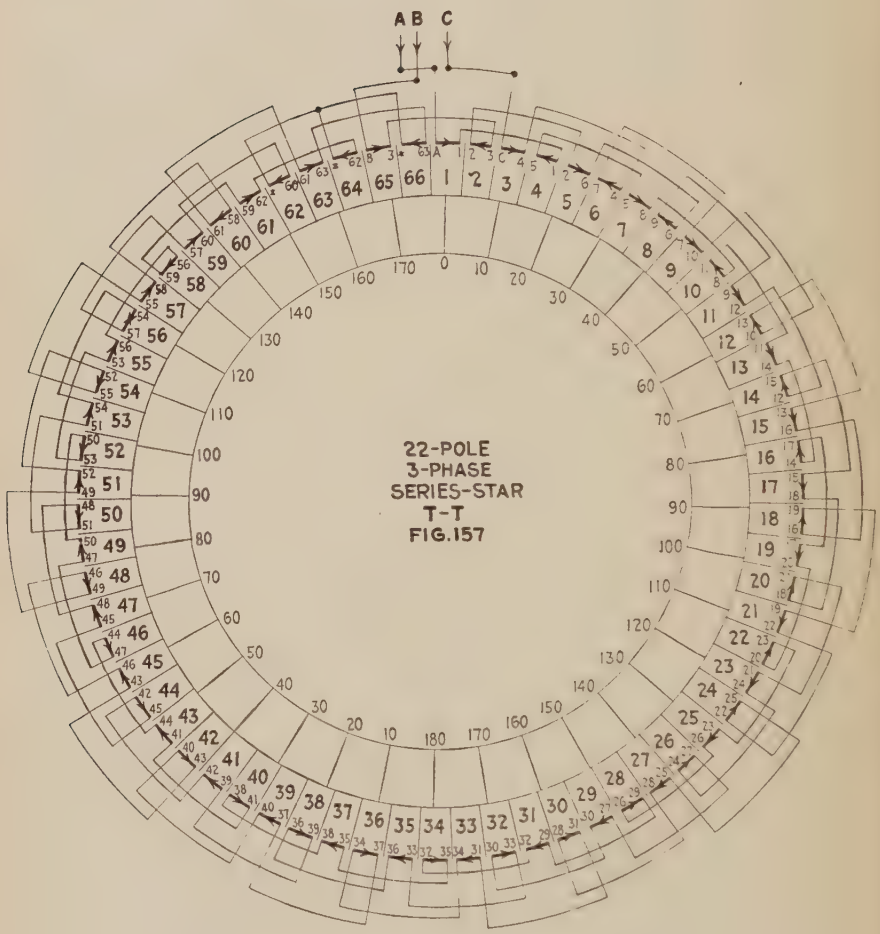

A B C
22-POLE
3-PHASE
SERIES-STAR
T-T
FIG. 157

TABLE 46.—CONNECTIONS FOR ENDS OF GROUPS OF 22-POLE, 3-PHASE, STAR *T-T* WINDINGS

Connect together ends of groups having the same numbers or letters. Letters indicate line leads. Star connections are indicated by (*).

22-pole, 3-phase Star, Top-to-top. See Fig. 157

Pole Number	I			II			III			IV			V			VI		
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	A	12	3C	45	12	67	45	89	67	10 11	89	12 13	10 11	14 15	12 13	16 17	14 15	18 19	16
2-parallel	"	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	"
11-parallel	"	" *	" "	" *	" B	" *	" A	" *	" C	" *	" B	" *	" A	" *	" C	" *	" B	" *	"
22-parallel	"	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C

Pole Number	VII			VIII			IX			X			XI		
Group Number	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Series	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	33 30	31 34
2-parallel	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	* "	" "	" *	" B	" *
11-parallel	A "	* "	C "	* "	B "	* "	A "	* "	C "	* "	B 30	* "	A 32	* 30	C 34
22-parallel	" *	" B	" *	" A	" *	" C	" *	" B	" *	" A	" *	" C	" *	" B	" *

Pole Number	XII			XIII			XIV			XV			XVI			XVII		
Group Number	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
Series	35 32	33 36	37 34	35 38	39 36	37 40	41 38	39 42	43 40	41 44	45 42	43 46	47 44	45 48	49 46	47 50	51 48	49 52
2-parallel	" A	" "	" C	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	"
11-parallel	* 32	B "	* 34	A "	* "	C "	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	* "	C "	"
22-parallel	" A	" *	" C	" *	" B	" *	" A	" *	" C	" *	" B	" *	" A	" *	" C	" *	" B	" *	*

Pole Number	XVIII			XIX			XX			XXI			XXII		
Group Number	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
Series	53 50	51 54	55 52	53 56	57 54	55 58	59 56	57 60	61 58	59 62	* 60	61 63	* 62	B 3	* 63
2-parallel	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	"
11-parallel	* "	B "	* "	A "	* "	C "	* "	B "	* "	A "	" "	C "	" "	" "	"
22-parallel	" A	" *	" C	" *	" B	" *	" A	" *	" C	" *	" B	" *	" A	" *	" C

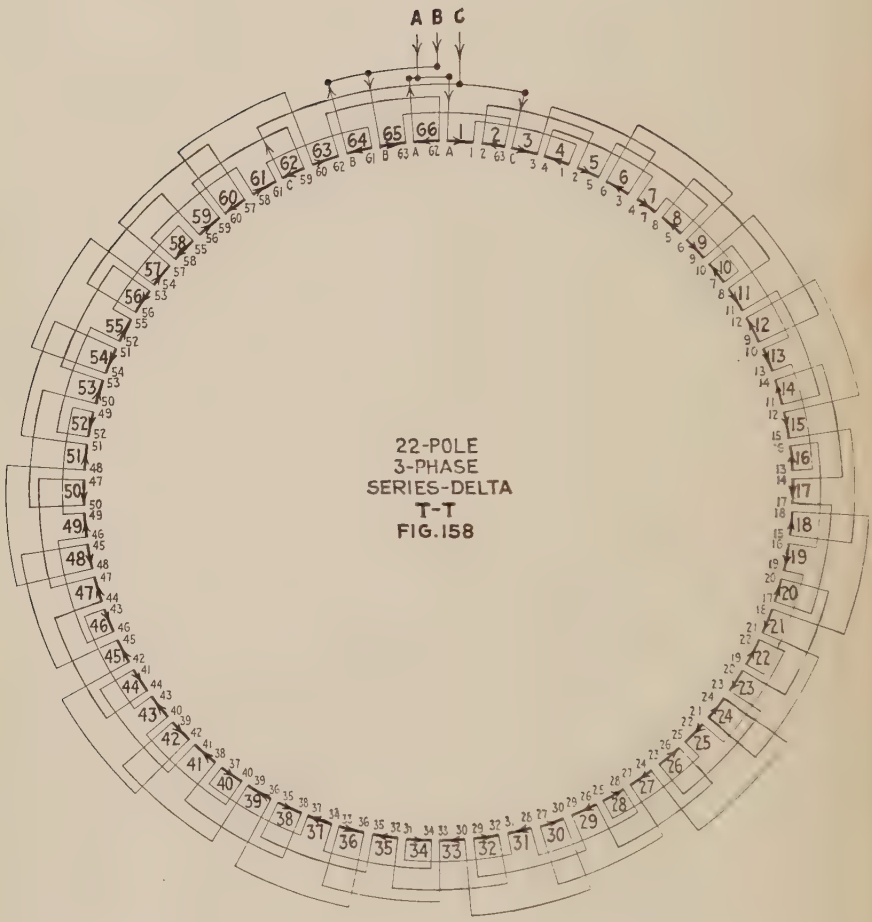

A B C
22-POLE
3-PHASE
SERIES-DELTA
T-T
FIG. 158

TABLE 47.—CONNECTIONS FOR ENDS OF GROUPS OF 22-POLE, 3-PHASE, DELTA *T-T* WINDINGS

Connect together ends of groups having same numbers or letters. Letters indicate line leads.

22-pole, 3 phase, Delta, Top-to-top. See Fig. 158

Pole Number	I			II			III			IV			V			VI		
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	A	1	2	6	3	C	3	4	1	2	5	6	3	4	7	8	5	6
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
11-parallel	"	"	C	"	"	"	B	"	B	"	A	"	A	"	C	"	C	"
22-parallel	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A

Pole Number	I			II			III			IV			V			VI		
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	9	10	7	8	11	12	9	10	13	14	11	12	15	16	13	14	17	18	15
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
11-parallel	"	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"
22-parallel	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C

Pole Number	VII			VIII			IX			X			XI		
Group Number	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Series	16	19	20	17	18	21	22	19	20	23	24	21	22	25	26	23	24	27	28	25	26	29	30	27	28	31	32	29	30	33
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	C	"	"	"	B	"	B	"	A
11-parallel	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	29	A	"	A	31	C	29	C	33
22-parallel	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A

Pole Number	XII			XIII			XIV			XV			XVI			XVII		
Group Number	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
Series	34	31	32	35	36	33	34	37	38	35	36	39	40	37	38	41	42	39	40	43	44	41	42	45	46	43	44	47	48	45	46	49	50	47	48	51
2-parallel	"	A	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
11-parallel	B	32	B	"	A	33	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"
22-parallel	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A

Pole Number	XVIII			XIX			XX			XXI			XXII		
Group Number	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
Series	52	49	50	53	54	51	52	55	56	53	54	57	58	55	56	59	60	57	58	61	C	59	60	62	B	61	B	63	A	62
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
11-parallel	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	"	"	C	"	"	"	"	"	"	"
22-parallel	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C

Chart X.—Unequal Coil Grouping for 22-pole, 2-phase, *T-T* Windings

22-pole, 2-phase, Top-to-top. See Fig. 156.

No. coils	Group Numbers																						No. large groups	No. small groups
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22		
54	2	2	1	1	1	1	1	1	1	1	2	2	1	1	1	1	2[k]	1	1	1	1	1	10	34
60	2	2	1	1	1	2	2	1	1	1	2	2	1	1	1	1	2	2	1	1	1	1	16	28
62	2	2	1	1	1	2	2	1	1	1	2	2	1	1	2–1	1	2	2	1	1	1	1	18	26
72	1	1	2	2	2	1	1	2	2	2	1	1	2	2	2	2	1	1	2	2	2	2	28	16
80	1	1	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2	2	2	2	36	8
84	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	40	4
86	1	2[k]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	42	2
90	3[k]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	42
96	3	3	2	2	2	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	8	36
104	3	3	2	2	2	3	3	2	2	2	3	3	2	2	2	2	3	3	2	2	2	2		
108	3	3	3	3	2	2	2	2	2	2	3	3	3	3	2	2	2	3	3	2	2	2	20	24
120	2	2	3	3	3	3	3	3	3	3	2	2	3	3	3	3	2	2	3	3	3	3	32	12
128	2	2	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3		
135	4[k]	3	3	3	3	3	3	3	3	3	3	3	4–1	3	3	3	3	3	3	3	3	3	3	41
144	4	4	3	3	3	3	3	3	3	3	4	4	3	3	3	3	4	4	3	3	3	3	12	32
150	4	4	3	3	3	4	4	3	3	3	4	4	3	3	4–1	3	4	4	3	3	3	3		
156	3	3	3	3	4	4	4	4	4	4	3	3	3	3	4	4	4	3	3	4	4	4	24	20
160	3	3	4	4	4	3	3	4	4	4	3	3	4	4	4	4	3	3	4	4	4	4		
168	3	3	4	4	4	4	4	4	4	4	3	3	4	4	4	4	4	4	4	4	4	4		
180	5[k]	4	4	4	4	4	4	4	4	4	4	5[k]	4	4	4	4	4	4	4	4	4	4	4	40
216	4	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5		
240	6	6	6	6	5	5	5	5	5	5	6	6	6	6	5	5	5	6	6	5	5	5		

No. coils	Group Numbers																						No. large groups	No. small groups
	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44		
54	2	2	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	2[k]	1	1	1	1	10	34
60	2	2	1	1	1	2	2	1	1	1	2	2	1	1	1	1	2	2	1	1	1	1	16	28
62	2	2	1	2–1	1	2	2	1	1	1	2	2	1	1	1	1	2	2	1	1	1	1	18	26
72	1	1	2	2	2	1	1	2	2	2	1	1	2	2	2	2	1	1	2	2	2	2	28	16
80	1	1	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2	2	2	2	36	8
84	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	40	4
86	2[k]	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	42	2
90	2	3[k]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	42
96	3	3	2	2	2	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	8	36
104	3	3	2	2	2	3	3	2	2	2	3	3	2	2	2	2	3	3	2	2	2	2		
108	3	3	3	3	2	2	2	2	2	2	3	3	3	3	2	2	2	3	3	2	2	2	20	24
120	2	2	3	3	3	3	3	3	3	3	2	2	3	3	3	3	2	2	3	3	3	3	32	12
128	2	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3		
135	3	4[k]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	41
144	3	4	3	3	3	3	3	3	3	3	4	4	3	3	3	3	4	4	3	3	3	3	12	32
150	4	4	3	4–1	3	4	4	3	3	3	4	4	3	3	3	3	4	4	3	3	3	3		
156	3	3	3	3	4	4	4	4	4	4	3	3	3	3	4	4	4	3	3	4	4	4	24	20
160	3	3	4	4	4	3	3	4	4	4	3	3	4	4	4	4	3	3	4	4	4	4		
1 8	3	3	4	4	4	4	4	4	4	4	3	3	4	4	4	4	4	4	4	4	4	4		
180	5[k]	4	4	4	4	4	4	4	4	4	4	5[k]	4	4	4	4	4	4	4	4	4	4	4	40
21	4	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5		
240	6	6	6	6	5	5	5	5	5	5	6	6	6	6	5	5	5	6	6	5	5	5		

[k] A coil is killed in each group where this symbol appears, provided it appears also in the Main Table or this winding (see pages 8–9).

Chart Y.—Unequal Coil Grouping for 22-pole, 3-phase, Star and Delta Windings

22-pole, 3-phase, Top-to-top. See Figs. 157 and 158

No. Coils	Group Numbers																														No. large groups	No. small groups
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33		
72	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	6	60
80	2	1	1	1	1	2	1	1	1	1	2	1	1	1	2–1	1	1	2	1	1	1	1	2	1	1	1	1	2	1	1	1	1	1	14	52
84	2	1	2	1	2	1	2	1	2	1	2	1	1	1	1	1	1	1	1	1	2	1	2	1	2	1	1	1	1	1	1	1	1	18	48
86	2	1	2	1	2	1	2	1	2	1	2	1	1	1	1	1	2–1	1	1	1	2	1	2	1	2	1	1	1	1	1	1	1	1	20	46
90	2	1	2	1	2	1	2	1	2	1	2	1	1	1	1	2	1	2	1	2	1	2	1	2	1	2	1	1	1	1	1	1	1	24	42
96	2	1	2	1	2	1	2	1	2	1	2	1	1	1	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	30	36
104	1	2	1	2	1	2	1	2	1	2	1	2	2	2	2	1	2	1	2	2–1	2	1	2	1	2	1	2	1	2	1	2	1	2	38	28
108	1	2	1	2	1	2	1	2	1	2	1	2	2	2	2	1	2	1	2	1	2	1	2	1	2	1	2	2	2	2	2	2	2	42	24
120	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	2	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	54	12
128	1	2	2	2	2	2	2	2	2	2	2	2–1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	62	4
135	3[k]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3[k]	2	2	2	2	2	2	2	2	2	2	3	63
144	3	2	2	2	2	3	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	3	2	2	2	2	3	2	2	2	2	2	12	54
150	3	2	3	2	3	2	3	2	3	2	3	2	2	2	2	2	2	2	2	2	3	2	3	2	3	2	2	2	2	2	2	2	2		
156	3	2	3	2	3	2	3	2	3	2	3	2	2	2	2	3	2	3	2	3	2	3	2	3	2	3	2	2	2	2	2	2	2		
160	3	2	3	2	3	2	3	2	3	2	3	2	3–1	2	3–1	3	2	3	2	3	2	3	2	3	2	3	2	2	2	2	2	2	2	28	38
168	2	3	2	3	2	3	2	3	2	3	2	3	3	3	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	36	30
180	2	3	2	3	2	3	2	3	2	3	2	3	3	3	3	3	3	3	3	3	2	3	2	3	2	3	3	3	3	3	3	3	3	48	18
216	4	3	4	3	4	3	4	3	4	3	4	3	3	3	3	3	3	3	3	4	3	4	3	4	3	4	3	3	3	3	3	3	3		
240	3	4	3	4	3	4	3	4	3	4	3	4	4	4	4	3	4	3	4	3	4	3	4	3	4	3	4	4	4	4	4	4	4		

No. Coils	Group Numbers																														No. large groups	No. small groups
	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66		
72	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	6	60
80	2	1	1	1	1	2	1	2–1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	2	1	1	1	1	2	1	1	1	1	1	14	52
84	2	1	2	1	2	1	2	1	2	1	2	1	1	1	1	1	1	1	1	1	2	1	2	1	2	1	1	1	1	1	1	1	1	18	48
86	2	1	2	1	2	1	2	1	2	1	2	1	1	1	2–1	1	1	1	1	1	2	1	2	1	2	1	1	1	1	1	1	1	1	20	46
90	2	1	2	1	2	1	2	1	2	1	2	1	1	1	1	2	1	2	1	2	1	2	1	2	1	2	1	1	1	1	1	1	1	24	42
96	2	1	2	1	2	1	2	1	2	1	2	1	1	1	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	30	36
104	1	2	2–1	2	1	2	1	2	1	2	1	2	2	2	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	38	28
108	1	2	1	2	1	2	1	2	1	2	1	2	2	2	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	2	2	2	2	42	24
120	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	2	1	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	54	12
128	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2–1	2	2	2	2	2	2	2	2	2	2	62	4
135	2	2	2	2	2	2	2	2	2	2	2	3[k]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	63
144	3	2	2	2	2	3	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	3	2	2	2	2	3	2	2	2	2	2	12	54
100	3	2	3	2	3	2	3	2	3	2	3	2	2	2	2	2	2	2	2	2	3	2	3	2	3	2	2	2	2	2	2	2	2		
156	3	2	3	2	3	2	3	2	3	2	3	2	2	2	2	3	2	3	2	3	2	3	2	3	2	3	2	2	2	2	2	2	2		
160	3	2	3	2	3	2	3	2	3	2	3	2	2	2	2	3	2	3	2	3	2	3	2	3	2	3	2	2	3–1	2	2	3–1	2	28	38
168	2	3	2	3	2	3	2	3	2	3	3	3	3	3	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	36	30
180	2	3	2	3	2	3	2	3	2	3	3	3	3	3	3	3	3	3	3	3	2	3	2	3	2	3	3	3	3	3	3	3	3	48	18
216	4	3	4	3	4	3	4	3	4	3	4	3	3	3	3	3	3	3	3	3	4	3	4	3	4	3	3	3	3	3	3	3	3		
240	3	4	3	4	3	4	3	4	3	4	4	4	4	4	4	3	4	3	4	3	4	3	4	3	4	3	4	4	4	4	4	4	4		

[k] A coil is killed in each group where this symbol appears, provided it appears also in the Main Table for this winding (see pages 8–9).

CHAPTER XXIX

TWENTY-FOUR, TWO- AND THREE-PHASE, STAR AND DELTA DIAGRAMS AND CONNECTING TABLES

On any twenty-four pole winding there are eight possible connections, namely, series, 2, 3, 4, 6, 8, 12, and 24-parallel. Thus a high voltage 3-phase machine can be reduced to a low line voltage with sixteen reconnections possible (star or delta) as indicated above.

The tables can be used to make up any diagram or the change can be laid direct on the winding from the tables.

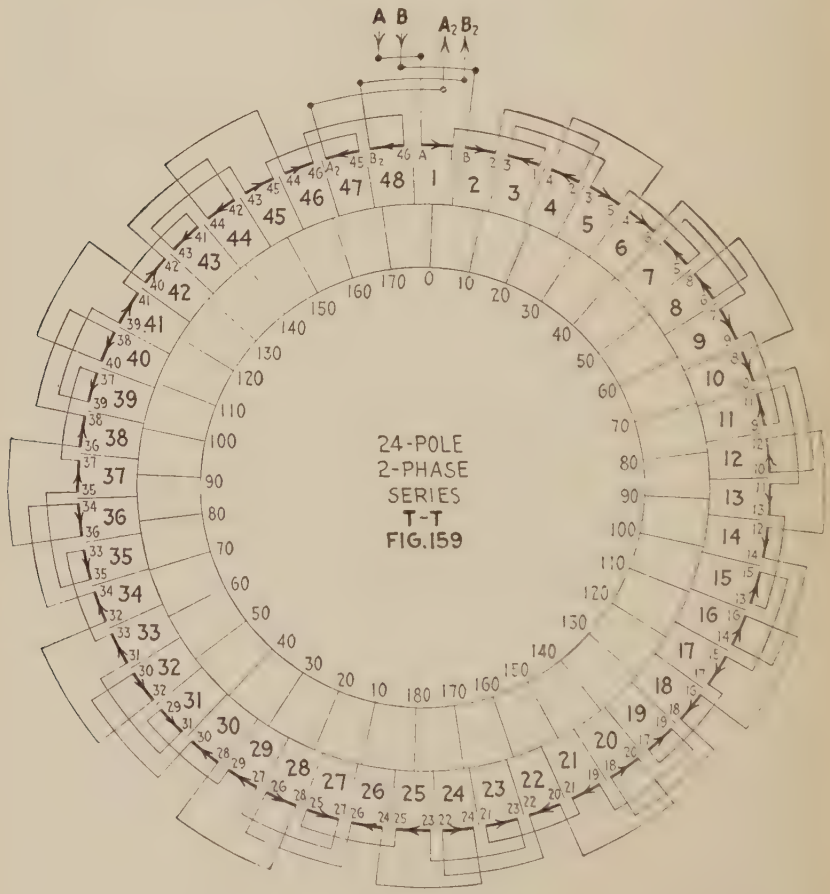


TABLE 48.—CONNECTIONS FOR ENDS OF GROUPS OF 24-POLE, 2-PHASE *T-T* WINDINGS

Correct together group ends having same number or letter. Letters indicate line leads.

24-pole, 2-phase, Top-to-top. See Fig. 159

Pole Number	I		II		III		IV		V		VI		VII		VIII		IX		X		XI		XII	
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14	15 17	16 18	19 17	20 18	19 21	20 22	23 21	24 22
2-parallel	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "
3-parallel	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	A "	B "	A "	B "	" "	" "	" "	" "	" "	" "	23 "	24 "
4-parallel	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B "	15 "	16 "	15 "	16 "	" "	" "	" "	" "	A_2 "	B_2 "
6-parallel	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B "	11 "	12 "	11 "	12 "	A_2 "	B_2 "	A "	B "	" "	" "	" "	" "	" "	" "
8-parallel	" "	" "	" "	" "	A_2 "	B_2 "	7 A	8 B	7 "	8 "	A_2 "	B_2 "	A "	B "	15 "	16 "	15 A_2	16 B_2	" A	" B	" "	" "	" "	" "
12-parallel	" "	" "	A_2 "	B_2 "	A 5	B 6	A_2 5	B_2 6	A "	B "	" "	" "	" "	" "	A_2 "	B_2 "	A 17	B 18	A_2 17	B_2 18	A "	B "	" "	" "
24-parallel	" A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B

Pole Number	XIII		XIV		XV		XVI		XVII		XVIII		XIX		XX		XXI		XXII		XXIII		XXIV	
Group Number	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Series	23 25	24 26	27 25	28 26	27 29	28 30	31 29	32 30	31 33	32 34	35 33	36 34	35 37	36 38	39 37	40 38	39 41	40 42	43 41	44 42	43 45	44 46	A_2 45	B_2 46
2-parallel	A "	B "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
3-parallel	23 "	24 "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
4-parallel	A "	B "	" "	" "	" "	" "	31 "	32 "	31 "	32 "	A_2 "	B_2 "	A "	B "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "	" "
6-parallel	" "	" "	" "	" "	" "	" "	A_2 "	B_2 "	A "	B "	35 "	36 "	35 "	36 "	A "	B_2 "	A "	B "	" "	" "	" "	" "	" "	" "	" "
8-parallel	" "	" "	" "	" "	" A_2	" B_2	31 A	32 B	31 "	32 "	A_2 "	B_2 "	A "	B "	39 "	40 "	39 A_2	40 B_2	" A	" B	" "	" "	" "	" "
12-parallel	" "	" "	A_2 "	B_2 "	A 29	B 30	A_2 29	B_2 30	A "	B "	" "	" "	" "	" "	A_2 "	B_2 "	A 41	B 42	A_2 41	B_2 42	A "	B "	" "	" "
24-parallel	" A_2 "	B_3 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B "	A_2 "	B_2 "	A "	B

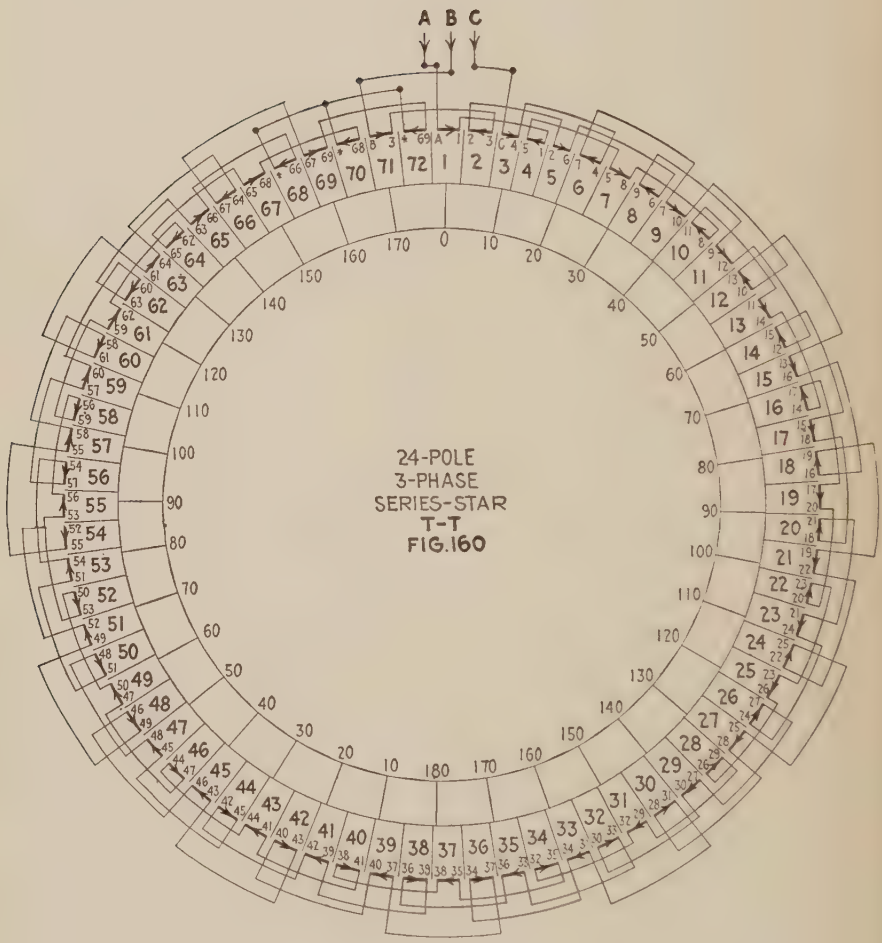

A B C
24-POLE
3-PHASE
SERIES-STAR
T-T
FIG. 160

TABLE 49.—CONNECTIONS FOR ENDS OF GROUPS OF 24-POLE, 3-PHASE, STAR *T-T* WINDINGS

Connect together ends of groups that have same numbers and letters. Letters indicate line leads. Star connections are indicated by (*).

24-pole, 3-phase Star, Top-to-top, See Fig. 160

Pole Number	I			II			III			IV			V			VI		
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	A	1	2	3	C	4	5	1	2	6	7	4	5	8	9	6	7	10
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
3-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
6-parallel	"	"	"	"	"	"	"	*	"	"	*	"	B	"	*	"	A	"
8-parallel	"	"	"	"	"	"	"	9	B	"	*11	A	9	"	13	C	11	"
12-parallel	"	"	*	"	"	*	"	B	6	*	"	A	8	*	6	C	10	*
24-parallel	"	*	"	B	"	*	"	A	*	"	C	"	*	"	B	"	*	"

Pole Number	I			II			III			IV			V			VI		
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	A	1	2	3	C	4	5	1	2	6	7	4	5	8	9	6	7	10
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
3-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
6-parallel	"	"	"	"	"	"	"	*	"	"	*	"	B	"	*	"	A	"
8-parallel	"	"	"	"	"	"	"	9	B	"	*11	A	9	"	13	C	11	"
12-parallel	"	"	*	"	"	*	"	B	6	*	"	A	8	*	6	C	10	*
24-parallel	"	*	"	B	"	*	"	A	*	"	C	"	*	"	B	"	*	"

Pole Number	VII			VIII			IX			X			XI			XII		
Group Number	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Series	17	20	21	18	19	22	23	20	21	24	25	22	23	26	27	24	25	28
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
3-parallel	"	*	"	"	"	*	"	B	"	*	"	"	A	"	"	C	"	"
4-parallel	A	"	21	"	C	"	23	"	21	"	25	"	23	"	"	"	25	"
6-parallel	17	"	*	"	19	"	*	"	B	"	*	"	A	"	"	"	C	"
8-parallel	A	"	21	"	C	"	23	"	21	*	25	*	23	*	"	B	25	*
12-parallel	"	"	*	"	"	*	"	B	24	*	"	A	26	*	24	C	28	*
24-parallel	"	*	"	B	"	*	"	A	*	"	C	"	*	"	B	"	*	"

Pole Number	VII			VIII			IX			X			XI			XII		
Group Number	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Series	17	20	21	18	19	22	23	20	21	24	25	22	23	26	27	24	25	28
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
3-parallel	"	*	"	"	"	*	"	B	"	*	"	"	A	"	"	C	"	"
4-parallel	A	"	21	"	C	"	23	"	21	"	25	"	23	"	"	"	25	"
6-parallel	17	"	*	"	19	"	*	"	B	"	*	"	A	"	"	"	C	"
8-parallel	A	"	21	"	C	"	23	"	21	*	25	*	23	*	"	B	25	*
12-parallel	"	"	*	"	"	*	"	B	24	*	"	A	26	*	24	C	28	*
24-parallel	"	*	"	B	"	*	"	A	*	"	C	"	*	"	B	"	*	"

Pole Number	XIII			XIV			XV			XVI			XVII			XVIII		
Group Number	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Series	35	38	39	36	37	40	41	38	39	42	43	40	41	44	45	42	43	46
2-parallel	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"
3-parallel	35	"	"	"	37	"	"	"	"	"	"	"	*	"	"	B	"	"
4-parallel	A	"	"	"	C	"	"	"	"	"	"	"	45	"	"	"	47	"
6-parallel	"	"	"	"	"	"	"	"	"	"	"	"	*	"	"	B	"	*
8-parallel	"	"	"	"	"	"	"	"	"	"	"	"	*45	B	"	*	47	A
12-parallel	"	"	*	"	"	*	"	B	42	*	"	A	44	*	42	C	46	*
24-parallel	"	*	"	B	"	*	"	A	*	"	C	"	*	"	B	"	*	"

Pole Number	XIII			XIV			XV			XVI			XVII			XVIII		
Group Number	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Series	35	38	39	36	37	40	41	38	39	42	43	40	41	44	45	42	43	46
2-parallel	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"
3-parallel	35	"	"	"	37	"	"	"	"	"	"	"	*	"	"	B	"	"
4-parallel	A	"	"	"	C	"	"	"	"	"	"	"	45	"	"	"	47	"
6-parallel	"	"	"	"	"	"	"	"	"	"	"	"	*	"	"	B	"	*
8-parallel	"	"	"	"	"	"	"	"	"	"	"	"	*45	B	"	*	47	A
12-parallel	"	"	*	"	"	*	"	B	42	*	"	A	44	*	42	C	46	*
24-parallel	"	*	"	B	"	*	"	A	*	"	C	"	*	"	B	"	*	"

Pole Number	XIX			XX			XXI			XXII			XXIII			XXIV		
Group Number	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Series	53	56	57	54	55	58	59	56	57	60	61	58	59	62	63	60	61	64
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
3-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"
6-parallel	53	"	*	"	55	"	*	"	B	"	*	"	A	"	"	C	"	"
8-parallel	A	"	57	"	C	"	59	"	57	*	61	"	59	*	"	B	61	*
12-parallel	"	"	*	"	"	*	"	B	60	*	"	A	62	*	60	C	64	*
24-parallel	"	*	"	B	"	*	"	A	*	"	C	"	*	"	B	"	*	"

Pole Number	XIX			XX			XXI			XXII			XXIII			XXIV		
Group Number	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Series	53	56	57	54	55	58	59	56	57	60	61	58	59	62	63	60	61	64
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
3-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"
6-parallel	53	"	*	"	55	"	*	"	B	"	*	"	A	"	"	C	"	"
8-parallel	A	"	57	"	C	"	59	"	57	*	61	"	59	*	"	B	61	*
12-parallel	"	"	*	"	"	*	"	B	60	*	"	A	62	*	60	C	64	*
24-parallel	"	*	"	B	"	*	"	A	*	"	C	"	*	"	B	"	*	"

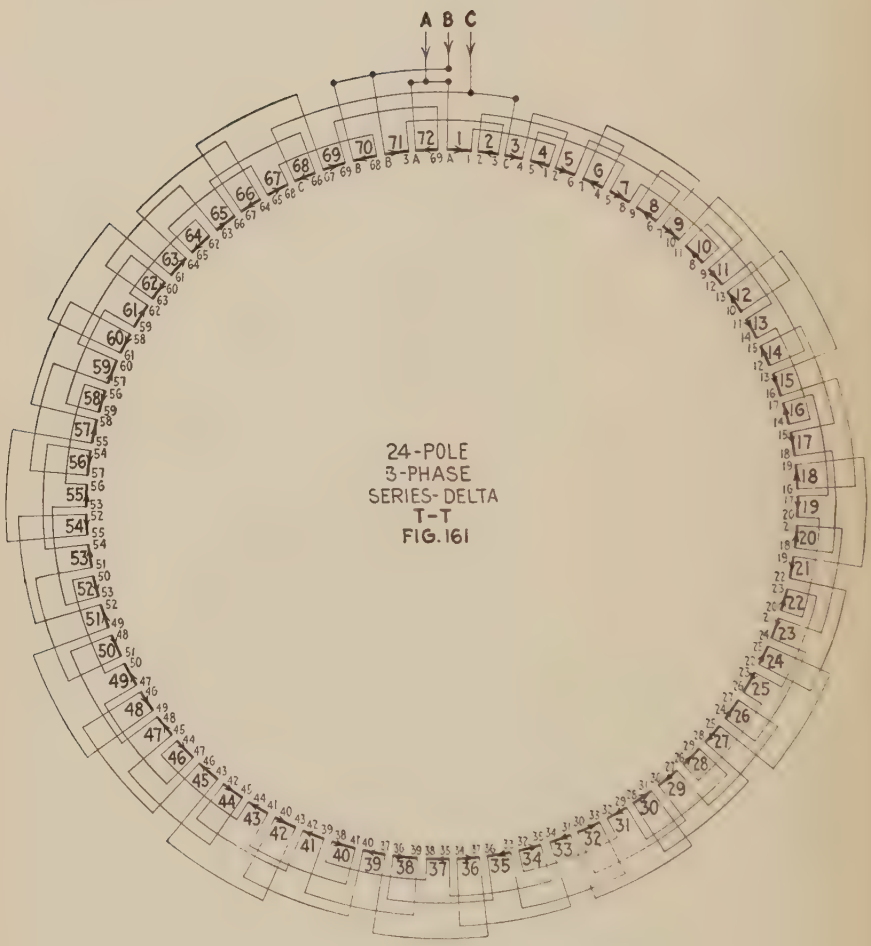

A B C
24-POLE
3-PHASE
SERIES-DELTA
T-T
FIG. 161

TABLE 50.—CONNECTIONS FOR ENDS OF GROUPS OF 24-POLE, 3-PHASE, DELTA *T-T* WINDINGS

Connect together ends of groups having same numbers or letters. Letters indicate line leads.

24-pole, 3-phase Delta, Top-to-top. See Fig. 161

Pole Number	I			II			III			IV			V			VI		
Group Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	A	1	2	3	C	4	5	1	2	6	7	4	5	8	9	6	7	10	11	8	9	12	13	10	11	14	15	12	13	16	17	14	15	18	19	16
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
3-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	C	"	"	"	B	"	B	"	A	"
6-parallel	"	"	"	"	"	"	"	"	"	"	C	"	"	B	"	B	"	A	"	A	"	15	"	C	"	17	"	15	"	19	"	"	"	"	"	"
8-parallel	"	"	"	"	"	"	"	C	"	"	B	9	B	"	A	11	A	9	"	13	C	11	"	C	"	13	"	B	"	B	"	A	"	"	"	"
12-parallel	"	"	C	"	"	"	B	"	B	6	A	"	A	8	C	6	C	10	B	"	8	B	"	A	10	A	"	"	"	C	"	"	"	"	"	"
24-parallel	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C

Pole Number	VII			VIII			IX			X			XI			XII		
Group Number	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Series	17	20	21	18	19	22	23	20	21	24	25	22	23	26	27	24	25	28	29	26	27	30	31	28	29	32	33	30	31	34	35	32	33	36	37	34
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	C	"	"	"	B	"	B	"	A	"
3-parallel	"	"	C	"	"	"	B	"	B	"	A	"	A	"	"	C	"	"	"	"	"	"	"	"	"	"	"	33	"	"	"	35	"	33	"	37	"
4-parallel	A	"	21	"	C	"	23	"	21	"	25	"	23	"	"	"	25	"	"	"	"	"	"	"	"	"	"	C	"	"	"	B	"	B	"	A	"
6-parallel	17	"	C	"	19	"	B	"	B	"	A	"	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
8-parallel	A	"	21	"	C	"	23	"	21	C	25	"	23	B	"	B	25	A	"	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"
12-parallel	"	"	C	"	"	"	B	"	B	24	A	"	A	26	C	24	C	28	B	26	B	"	A	28	A	"	"	"	C	"	"	"	"	"	"	"	"
24-parallel	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C

Pole Number	XIII			XIV			XV			XVI			XVII			XVIII		
Group Number	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Series	35	38	39	36	37	40	41	38	39	42	43	40	41	44	45	42	43	46	47	44	45	48	49	46	47	50	51	48	49	52	53	50	51	54	55	52
2-parallel	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
3-parallel	35	"	"	"	37	"	"	"	"	"	"	"	"	C	"	"	"	"	"	B	"	B	"	A	"	A	"	"	"	C	"	"	"	"	"	"	"	"
4-parallel	A	"	"	"	C	"	"	"	"	"	"	"	"	45	"	"	"	"	"	47	"	45	"	49	"	47	"	C	"	49	"	B	"	B	"	A	"
6-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	C	"	"	"	"	"	B	"	B	"	A	"	A	"	51	"	C	"	53	"	51	"	55	"
8-parallel	"	"	"	"	"	"	"	C	"	"	"	"	"	B	45	B	"	A	47	A	45	"	49	C	47	"	C	"	49	"	B	"	B	"	A	"	"
12-parallel	"	"	C	"	"	"	B	"	B	42	A	"	A	44	C	42	C	46	B	44	B	"	A	46	A	"	"	"	C	"	"	"	"	"	"	"	"
24-parallel	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C

Pole Number	XIX			XX			XXI			XXII			XXIII			XXIV		
Group Number	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Series	53	56	57	54	55	58	59	56	57	60	61	58	59	62	63	60	61	64	65	62	63	66	67	64	65	68	C	66	67	69	B	68	B	3	A	69
2-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
3-parallel	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
4-parallel	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
6-parallel	53	"	C	"	55	"	B	"	B	"	A	"	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
8-parallel	A	"	57	"	C	"	59	"	57	C	61	"	59	B	"	B	61	A	"	A	"	"	"	C	"	"	"	"	"	"	"	"	"	"	"	"	"	"
12-parallel	"	"	C	"	"	"	B	"	B	60	A	"	A	62	C	60	C	64	B	62	B	"	A	64	A	"	"	"	C	"	"	"	"	"	"	"	"
24-parallel	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C	"	B	"	B	"	A	"	A	"	C	"	C

CHART Z(1).—UNEQUAL COIL GROUPING FOR 24-POLE, 2-PHASE, *T-T* WINDINGS
24-pole, 2-phase, Top-to-top. See Fig. 159

No. coils	Group Numbers																						No. large groups	No. small groups
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
54	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	6	42
60	2	2	1	1	1	1	1	1	2k	2k	1	1	1	1	1	1	2	2	1	1	1	1	1	1	12	36
62	2	2	1	1	2–1	1	1	1	2	2	1	1	1	1	1	1	2	2	1	1	1	1	1	1	14	34
72	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	24	24
80	1	1	2	2	2	2	1	1	2	2	2	2	1	1	2	2	2	2	1	1	2	2	2	2	32	16
84	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	36	12
86	1	1	2	2	2	2	2	2	1	2–1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	38	10
90	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2	2	42	6
104	3	3	2	2	2	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	2	2	8	40
108	3	3	2	2	2	2	2	2	3k	3k	2	2	2	2	2	2	3	3	2	2	2	2	2	2		
120	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2		
128	2	2	3	3	3	3	2	2	3	3	3	3	2	2	3	3	3	3	2	2	3	3	3	3		
135	2	2	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3	3	3	3	2	2	3	3	9	39
150	4k	4k	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4k	4k	3	3	3	3	3	3		
156	4	4	3	3	3	3	3	3	4k	4k	3	3	3	3	3	3	4	4	3	3	3	3	3	3		
160	4	4	3	3	3	3	4	4	3	3	3	3	4	4	3	3	3	3	4	4	3	3	3	3	16	32
168	4	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3		
180	3	3	4	4	4	4	4	4	3	3	4	4	4	4	4	4	3	3	4	4	4	4	4	4		
216	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4		

No. coils	Group Numbers																						No. large groups	No. small groups
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48		
54	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	6	42
60	2	2	1	1	1	1	1	1	2k	2k	1	1	1	1	1	1	2	2	1	1	1	1	1	1	12	36
62	2	2	1	1	1	2–1	1	1	2	2	1	1	1	1	1	1	2	2	1	1	1	1	1	1	14	34
72	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	24	24
80	1	1	2	2	2	2	1	1	2	2	2	2	1	1	2	2	2	2	1	1	2	2	2	2	32	16
84	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	36	12
86	1	1	2	2	2	2	2	2	2–1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	38	10
90	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	42	6
104	3	3	2	2	2	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	2	2	8	40
108	3	3	2	2	2	2	2	2	3k	3k	2	2	2	2	2	2	3	3	2	2	2	2	2	2		
120	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2		
128	2	2	3	3	3	3	2	2	3	3	2	2	3	3	3	3	2	2	3	3	3	3	3	3		
135	3	3	3	3	2	3–1	3	3	3	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	9	39
150	3	3	3	3	3	3	3	3	4k	4k	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
156	4	4	3	3	3	3	3	3	4k	4k	3	3	3	3	3	3	4	4	3	3	3	3	3	3		
160	4	4	3	3	3	3	4	4	3	3	3	3	4	4	3	3	3	3	4	4	3	3	3	3	16	32
168	4	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3		
180	3	3	4	4	4	4	4	4	3	3	4	4	4	4	4	4	3	3	4	4	4	4	4	4		
216	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4	4		

k A coil is killed in each group where this symbol appears, provided it appears also in the Main Table for this winding (see pages 8–9).

Chart Z(2).—Unequal Coil Grouping for 24-pole, 3-phase Star and Delta Windings

24-pole, 3-phase, Top-to-top. See Figs. 160 and 161

No. coils	Group Numbers																															No. large groups	No. small groups
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
80	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2–1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	8	64
84	2	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	12	60
86	2	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	2	1	1	1	2–1	1	1	2	1	1	1	1	1	1	2	1	1	1	14	58
90	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	18	54
96	2	1	1	1	2	1	1	1	2	2	1	1	1	2	1	1	1	2	2	1	1	1	2	1	1	1	2	2	1	1	1	2	1	1	1	2	24	48
104	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	32	40
108	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	36	36
120	1	2	2	2	1	2	2	2	1	1	2	2	2	1	2	2	2	1	1	2	2	2	1	2	2	2	1	1	2	2	2	1	2	2	2	1	48	24
128	1	2	2	2	1	2	2	2	2–1	2	2	2	1	2	2	2	2	1	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	56	16
135	1	2	2	2k	2	2	2	2	1	2	2	2	2k	2	2	2	1	2	2	2	2k	2	2	2	1	2	2	2	2k	2	2	2	1	2	2	2	63	9
150	3k	2	2	2	2	2	2	2	2	2	2	2	2	3k	2	2	2	2	2	2	2	2	2	2	2	2	3k	2	2	2	2	2	2	2	2	2	6	66
156	3	2	2	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	3	2	2	2	2	2		
160	3	2	2	2	2	2	3	2	2	2	2	2	2	2	3	2	2	2	3	2	2	2	3–1	2	2	3	2	2	2	2	2	2	3	2	2	2	16	56
168	3	2	2	2	3	2	2	2	3	3	2	2	2	3	2	2	2	3	3	2	2	2	3	2	2	2	3	3	2	2	2	3	2	2	2	3		
180	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2		
240	4	3	3	3	4	3	3	3	4	4	3	3	3	4	3	3	3	4	4	3	3	3	4	3	3	3	4	4	3	3	3	4	3	3	3	4		

No. coils	Group Numbers																																	No. large groups	No. small groups
	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	2	63	64	65	66	67	68	69	70	71	72		
80	2	1	1	1	1	1	1	2–1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	8	64
84	2	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	12	60
86	2	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	2	1	1	1	2–1	1	1	2	1	1	1	1	1	1	2	1	1	1	14	58
90	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	18	54
96	2	1	1	1	2	1	1	1	2	2	1	1	1	2	1	1	1	2	2	1	1	1	2	1	1	1	2	2	1	1	1	2	1	1	1	1	24	48
104	2	2	2	2	2	2	1	1	1	2–1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	2	2	2	1	1	1	1	2–1	1	32	40
108	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	36	36
120	1	2	2	2	1	2	2	2	1	1	2	2	2	1	2	2	2	1	1	2	2	2	1	2	2	2	1	1	2	2	2	1	2	2	2	1	48	24
128	1	2	2	2	1	2	2	2	2–1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	56	16
135	2k	2	2	2	1	2	2	2	2k	2	2	2	1	2	2	2	2k	2	2	2	1	2	2	2	2k	2	2	2	1	2	2	2	2k	2	2	2	63	9
150	3k	2	2	2	2	2	2	2	2	2	2	2	2	3k	2	2	2	2	2	2	2	2	2	2	2	2	3k	2	2	2	2	2	2	2	2	2	6	66
156	3	2	2	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2		
160	3	2	2	3–1	2	2	2	3	2	2	2	3–1	2	2	3	2	2	2	3	2	2	2	3–1	2	2	3	2	2	2	3	2	2	3	2	2	2	16	56
168	3	2	2	2	3	2	2	2	3	3	2	2	2	3	2	2	2	3	3	2	2	2	3	2	2	2	3	3	2	2	2	3	2	2	2	3		
180	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2		
240	4	3	3	3	4	3	3	3	4	4	3	3	3	4	3	3	3	4	4	3	3	3	4	3	3	3	4	4	3	3	3	4	3	3	3	4		

[k] A coil is killed in each group where this symbol appears, provided it appears also in the Main Table for this winding (see pages 8–9).

FINDING INDEX FOR CONNECTING DIAGRAMS

Number of Poles	Number of Phases	Type of Connection	Top to Top or Top to Bottom	Fig. No. to Use	Page No.
2	2	Series	T-T	18	61
	2	2 Parallel	T-T	19	61
	3	Series Star	T-T	20	63
	3	2 Parallel Star	T-T	21	63
	3	Series Delta	T-T	22	65
	3	2 Parallel Delta	T-T	23	65
4	2	Series	T-T	24	67
	2	2 Parallel	T-T	25	68
	2	Series	T-B	26	70
	2	2 Parallel	T-B	27	71
	2	4 Parallel	T-T and T-B	28	71
	3	Series Star	T-T	29	75
	3	2 Parallel Star	T-T	30	75
	3	Series Star	T-B	31	77
	3	2 Parallel Star	T-B	32	77
	3	4 Parallel Star	T-T and T-B	33	78
	3	Series Delta	T-T	34	81
	3	2 Parallel Delta	T-T	35	81
	3	Series Delta	T-B	36	82
	3	2 Parallel Delta	T-B	37	83
	3	4 Parallel Delta	T-T and T-B	38	83
6	2	Series	T-T	39	86
	2	2 Parallel	T-T	40	86
	2	3 Parallel	T-T	41	87
	2	Series	T-B	42	87
	2	2 Parallel	T-B	43	88
	2	3 Parallel	T-B	44	88
	2	6 Parallel	T-T and T-B	45	89
	3	Series Star	T-T	46	92
	3	2 Parallel Star	T-T	47	92
	3	3 Parallel Star	T-T	48	94
	3	Series Star	T-B	49	94
	3	2 Parallel Star	T-B	50	95
	3	3 Parallel Star	T-B	51	95
	3	6 Parallel Star	T-T and T-B	52	96

Number of Poles	Number of Phases	Type of Connection	Top to Top or Top to Bottom	Fig. No. to Use	Page No.
	3	Series Delta	T-T	53	96
	3	2 Parallel Delta	T-T	54	99
	3	3 Parallel Delta	T-T	55	99
6	3	Series Delta	T-B	56	100
	3	2 Parallel Delta	T-B	57	100
	3	3 Parallel Delta	T-B	58	101
	3	6 Parallel Delta	T-T and T-B	59	101
	2	Series	T-T	60	105
	2	2 Parallel	T-T	61	106
	2	4 Parallel	T-T	62	106
8	2	Series	T-B	63	107
	2	2 Parallel	T-B	64	107
	2	4 Parallel	T-B	65	108
	2	8 Parallel	T-T and T-B	66	108
	3	Series Star	T-T	67	111
	3	2 Parallel Star	T-T	68	111
	3	4 Parallel Star	T-T	69	112
8	3	Series Star	T-B	70	112
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	3	2 Parallel Delta	T-B	78	119
	3	4 Parallel Delta	T-B	79	120
	3	8 Parallel Delta	T-T and T-B	80	120
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	2	10 Parallel	T-T and T-B	87	126
	3	Series Star	T-T	88	129
	3	2 Parallel Star	T-T	89	129
	3	5 Parallel Star	T-T	90	130
10	3	Series Star	T-B	91	130
	3	2 Parallel Star	T-B	92	132
	3	5 Parallel Star	T-B	93	132
	3	10 Parallel Star	T-T and T-B	94	133

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	3	2 Parallel Delta	T-T	96	137
	3	5 Parallel Delta	T-T	97	137
10	3	Series Delta	T-B	98	139
	3	2 Parallel Delta	T-B	99	139
	3	5 Parallel Delta	T-B	100	140
	3	10 Parallel Delta	T-T and T-B	101	140
	2	Series	T-T	102	142
	2	2 Parallel	T-T	103	142
	2	3 Parallel	T-T	104	144
	2	4 Parallel	T-T	105	144
	2	6 Parallel	T-T	106	145
12	2	Series	T-B	107	145
	2	2 Parallel	T-B	108	146
	2	3 Parallel	T-B	109	146
	2	4 Parallel	T-B	110	147
	2	6 Parallel	T-B	111	147
	2	12 Parallel	T-T and T-B	112	148
	3	Series Star	T-T	113	148
	3	2 Parallel Star	T-T	114	150
	3	3 Parallel Star	T-T	115	150
	3	4 Parallel Star	T-T	116	152
	3	6 Parallel Star	T-T	117	152
12	3	Series Star	T-B	118	154
	3	2 Parallel Star	T-B	119	154
	3	3 Parallel Star	T-B	120	156
	3	4 Parallel Star	T-B	121	156
	3	6 Parallel Star	T-B	122	157
	3	12 Parallel Star	T-T and T-B	123	157
	3	Series Delta	T-T	124	160
	3	2 Parallel Delta	T-T	125	160
	3	3 Parallel Delta	T-T	126	162
	3	4 Parallel Delta	T-T	127	162
	3	6 Parallel Delta	T-T	128	163
12	3	Series Delta	T-B	129	163
	3	2 Parallel Delta	T-B	130	164
	3	3 Parallel Delta	T-B	131	164
	3	4 Parallel Delta	T-B	132	166
	3	6 Parallel Delta	T-B	133	166
	3	12 Parallel Delta	T-T and T-B	134	167
	2	Series	T-T	135	170
14	2	2 Parallel	T-T	136	170
	2	7 Parallel	T-T	137	172
	2	14 Parallel	T-T	138	172

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	3	2 Parallel Star	T-T	140	174
	3	7 Parallel Star	T-T	141	176
	3	14 Parallel Star	T-T	142	176
14	3	Series Delta	T-T	143	177
	3	2 Parallel Delta	T-T	144	177
	3	7 Parallel Delta	T-T	145	178
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16	2	Series	T-T	147	182
	3	Series Star	T-T	148	182
	3	Series Delta	T-T	149	186
18	2	Series	T-T	150	190
	3	Series Star	T-T	151	190
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20	2	Series	T-T	153	196
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2	3	Star and Delta	T-T	Figs. 20 to 23	2	64
4	2		T-T	Figs. 24, 25 and 28	3	67
4	2		T-B	Figs. 26 to 28	4	70
4	3	Star	T-T	Figs. 29, 30 and 33	5	74
4	3	Star	T-B	Figs. 31 to 33	6	76
4	3	Delta	T-T	Figs. 34, 35 and 38	7	80
4	3	Delta	T-B	Figs. 36 to 38	8	82
6	2		T-T	Figs. 39, 40, 41 and 45	9	85
6	2		T-B	Figs. 42 to 45	10	85
6	3	Star	T-T	Figs. 46, 47, 48, and 52	11	93
6	3	Star	T-B	Figs. 49 to 52	12	93
6	3	Delta	T-T	Figs. 53, 54, 55 and 59	13	98
6	3	Delta	T-B	Figs. 56 to 59	14	98
8	2		T-T	Figs. 60, 61, 62 and 66	15	104
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8	3	Star	T-T	Figs. 67, 68, 69 and 73	17	110
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8	3	Delta	T-T	Figs. 74, 75, 76 and 80	19	118
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10	2		T-T	Figs. 81, 82, 83 and 87	21	123
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12	2		T-B	Figs. 107 to 112	28	143
12	3	Star	T-T	Figs. 113, 114, 115, 116, 117 and 123	29	151
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16	3	Star	T-T	Fig. 148	37	184
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18	3	Star	T-T	Fig. 151	40	192
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20	2		T-T	Fig. 153	42	197
20	3	Star	T-T	Fig. 154	43	199
20	3	Delta	T-T	Fig. 155	44	201
22	2		T-T	Fig. 156	45	205
22	3	Star	T-T	Fig. 157	46	207
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	3 "	" B	T-T	62
4 pole	2 phase	" C	T-T and T-B	69
	3 "	" D	T-T " T-B star and delta	73
6 pole	2 phase	" E	T-T	85
	3 "	" F	T-T and T-B star and delta	91

No. of Poles	No. of Phases	Chart to Use	Type of Connection	Page No.
8 pole	2 phase	" G	T-T	103
	3 "	" H	T-T and T-B star and delta	115
10 pole	2 phase	" K	T-T	121
	3 "	" L	T-T and T-B Star and delta	134
12 pole	2 phase	" M	T-T	141
	3 "	" N(1)	T-T star and delta	153
	3 "	" N(2)	T-B star and delta	158
14 pole	2 phase	" P	T-T	169
	3 "	" Q	T-T star and delta	173
16 pole	2 phase	" R	T-T	181
	3 "	" S	T-T star and delta	185
18 pole	2 phase	" T	T-T	189
	3 "	" U	T-T star and delta	193
20 pole	2 phase	" V	T-T	202
	3 "	" W	T-T star and delta	203
22 pole	2 phase	" X	T-T	210
	3 "	" Y	T-T star and delta	211
24 pole	2 phase	" Z(1)	T-T	218
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